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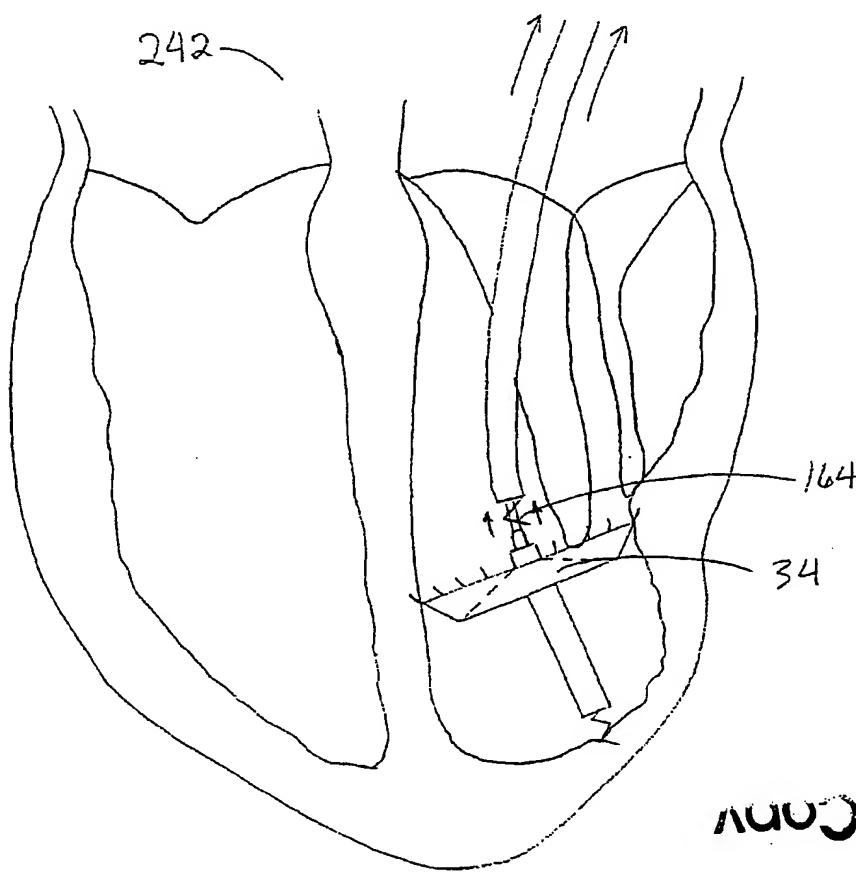
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(54) Title: A SYSTEM FOR IMPROVING CARDIAC FUNCTION



(57) Abstract: A system for improving cardiac function is provided. A foldable and expandable frame having at least one anchoring formation is attached to an elongate manipulator and placed in a catheter tube while folded. The tube is inserted into a left ventricle of a heart where the frame is ejected from the tube and expands in the left ventricle. Movements of the elongate manipulator cause the anchor to penetrate the heart muscle and the elongate manipulator to release the frame. The installed frame minimizes the effects of an akinetic portion of the heart forming an aneurysmic bulge.

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A SYSTEM FOR IMPROVING CARDIAC FUNCTION

BACKGROUND OF THE INVENTION

1). Field of the Invention

[0001] Embodiments of this invention relate to a method and device for improving cardiac function.

2). Discussion of Related Art

[0002] Congestive heart failure annually leads to millions of hospital visits internationally. Congestive heart failure is the description given to a myriad of symptoms that can be the result of the heart's inability to meet the body's demand for blood flow. In certain pathological conditions, the ventricles of the heart become ineffective in pumping the blood, causing a back-up of pressure in the vascular system behind the ventricle.

[0003] The reduced effectiveness of the heart is usually due an enlargement of the heart. A myocardial ischemia may, for example, cause a portion of a myocardium of the heart to lose its ability to contract. Prolonged ischaemia can lead to infarction of a portion of the myocardium (heart muscle) wherein the heart muscle dies and becomes scar tissue. Once this tissue dies it no longer functions as a muscle and cannot contribute to the pumping action of the heart. When the heart tissue is no longer pumping effectively, that portion of the myocardium is said to be hypokinetic, meaning that it is less contractile than the uncompromised myocardial tissue. As this situation worsens, the local area of compromised myocardium may in fact bulge out as the heart contracts, further decreasing the heart's ability to move blood forward. When local wall motion moves in this way, it is said to be dyskinetic, or akinetic. The dyskinetic portion of the myocardium may stretch and eventually form

an aneurysmic bulge. Certain diseases may cause a global dilated myopathy, i.e., a general enlargement of the heart when this situation continues for an extended period of time.

[0004] As the heart begins to fail, distilling pressures increase, which stretches the ventricular chamber prior to contraction and greatly increases the pressure in the heart. In response, the heart tissue reforms to accommodate the chronically increased filling pressures, further increasing the work that the now comprised myocardium must perform.

[0005] This vicious cycle of cardiac failure results in the symptoms of congestive heart failure, such as shortness of breath on exertion, edema in the periphery, nocturnal dyspnea (a characteristic shortness of breath that occurs at night after going to bed), waking, and fatigue, to name a few. The enlargements increase stress on the myocardium. The stress increase requires a larger amount of oxygen supply, which can result in exhaustion of the myocardium leading to reduced cardiac output of the heart.

SUMMARY OF THE INVENTION

[0007] The invention provides an apparatus for improving cardiac function comprising at least one external actuator, an elongate manipulator connected to the external actuator, a manipulator-side engagement component on a distal end of the elongate manipulator, a collapsible and expandable frame, a frame-side engagement component releasably engageable with the manipulator side-engagement component so that the external actuator can steer the frame when collapsed into a ventricle of a heart whereafter the frame is expanded, and at least one anchor connected to the frame, movement of the external actuator allowing for (i) insertion of the anchor and (ii) a myocardium ventricle, (iii) subsequent withdrawal of the

anchor of the myocardium, (iv) subsequent reinsertion of the anchor into the myocardium, said insertion securing the frame to the myocardium in a selected position, and (v) subsequent disengagement of the manipulator-side engagement component from the frame-side engagement component, said disengagement for releasing the frame from the elongate manipulator.

[0008] The frame may have a small cross-dimension when collapsed suitable for being inserted into the ventricle of the heart through a tubular passage in a large cross-dimension when expanded in the ventricle.

[0009] The frame may comprise plurality of segments extending from a central portion of the frame.

[0010] The frame may be made of nickel titanium or stainless steel.

[0011] The apparatus may further comprise a membrane stretched between the segments, the membrane dividing the ventricle into at least two volumes. The membrane may be made of ePTFE. The membrane may be a mesh.

[0012] The segments may further comprise first and second portions connected at ends thereof such that the second portions are at an angle to the first portions.

[0013] The frame may have proximal and distal sections. The frame may have a diameter of between 10 mm and 100 mm when expanded.

[0014] The apparatus may further comprise at least one active anchor and at least one passive anchor. Said insertion of the passive anchor may be in a first direction and said withdrawal of the passive anchor may be in a second direction, the second direction being substantially 180 degrees from the first direction.

[0015] The apparatus may further comprise a first passive anchor extending in the first direction and a second passive anchor extending in a third direction. The active and passive anchors may have sharp ends that penetrate the myocardium.

[0016] The apparatus may further comprise a tubular passage with a distal end suitable to be inserted into the ventricle.

[0017] The elongate manipulator may further comprise a frame member with proximal and distal ends and an anchor member with proximal and distal ends, the frame and anchor members being moveable through the tubular passage.

[0018] The manipulator side-engagement component may further comprise a frame formation on the distal end of the frame member and an anchoring formation on the distal end of the anchor member.

[0019] The apparatus may further comprise an external frame actuator connected to the proximal end of the frame member and an external anchor actuator connected to the proximal end of the anchor member.

[0020] When the distal end of the elongate manipulator is in the selected position, a first movement of the external anchor actuator may cause the active anchor to be inserted into the myocardium to secure the frame to the myocardium and a second movement of the external anchor actuator may cause the active anchor to withdraw from the myocardium, said withdrawal releasing the frame from the myocardium.

[0021] A first movement of the external frame actuator may cause the frame formation to engage the frame-side engagement component, said engagement securing the frame to the distal end of the elongate manipulator and a second movement of the external frame actuator may cause the frame formation to disengage the frame-side engagement component, said disengagement releasing the frame from the elongate manipulator.

[0022] The frame may be shaped such that entry of the proximal section of the frame into the tubular passage causes the frame to partially collapse such that the passive anchor withdraws from the myocardium in the second direction and entry of

the distal section of the frame into the tubular passage causes the frame to collapse to the small cross-section so that the distal end of the elongate manipulator and the frame can be removed from the heart.

[0023] The elongate manipulator and the frame may be insertable into the heart simultaneously and the frame may be shaped such that exposure of the distal section of the frame from the distal end of the tubular passage allows the frame to partially expand and exposure of the proximal section of the frame from the distal end of the tubular passage allows the frame to expand to a large cross-section, said expansion causing the passive anchors to penetrate the myocardium to secure the frame to the myocardium.

[0024] The invention also provides an apparatus for improving cardiac function comprising a frame which includes a plurality of central segments surrounding a central axis, the central segments having first and second ends, the first ends being pivotally connected to one another, and a plurality of outer segments having first and second ends, the first ends being pivotally secured to the second ends of the central segments, a membrane secured to the frame such that movement of the second ends of the central segments away from the central axis causes the membrane to unfold, the unfolding of the membrane causing the outer segments to pivot relative to the respective central segments away from the central axis and movement of the second ends of the central segments toward the central axis causes the membrane to fold, the folding of the membrane causing the outer segments to pivot relative to their respective central segments toward the central axis, and an anchor connected to the frame, the anchor being insertable into a myocardium of a heart to secure the cardiac device to the myocardium in a ventricle of the heart.

[0025] The frame may include at least three central segments and at least three

outer segments.

[0026] The membrane may be stretched between the central and the outer segments.

[0027] The anchor may be secured directly to the frame.

[0028] The invention further provides an apparatus for improving cardiac function comprising a frame, a membrane, having an inner surface, secured to the frame, the membrane and the frame jointly forming a cardiac device being moveable between a collapsed and an expanded state, in a collapsed state at least a portion of the inner surface of the membrane facing a vertical axis of the cardiac device and the cardiac device being insertable into a ventricle of a heart, in the expanded state the portion of the inner surface of the membrane facing away from the vertical axis and being in contact with a myocardium and the cardiac device being in a selected position in the ventricle, and an anchor connected to the cardiac device, the anchor being insertable into the myocardium of the heart to secure the cardiac device to the myocardium in the selected position in the ventricle.

[0029] The cardiac device may collapse toward the vertical axis and expand away from the vertical axis.

[0030] The membrane may fold towards the vertical axis when the cardiac device collapses and may unfold away from the vertical axis when the cardiac device expands.

[0031] The frame may be at least one of nickel titanium and stainless steel.

[0032] The membrane may be made of ePTFE.

[0033] The anchor may have a sharp end.

[0034] The invention further provides an apparatus for improving cardiac function comprising a frame being expandable in a selected position to a pre-set shape in a

ventricle of a heart, a formation on the frame, and an anchoring device having an anchor, the anchoring device being engaged with and rotatable relative the formation to rotate the anchor relative to the frame, said rotation causing the anchor to be inserted into a myocardium of the heart, said insertion securing the frame in the selected position in the ventricle.

[0035] The anchoring device may engage the formation such that a first rotation of the anchoring device causes the anchor to move away from the frame and a second rotation of the anchoring device causes the anchor to move toward the frame.

[0036] The formation may be a pin, and the anchor may be a screw.

[0037] The invention further provides an apparatus for improving cardiac function comprising at least a primary expandable frame being in a selected position in a ventricle of a heart when expanded, an anchor connected to the frame, the anchor being insertable into a myocardium of the heart to secure the primary frame within the ventricle, a frame-side engagement component connected to the primary frame, a membrane, and a membrane-side engagement component being engageable with the frame-side engagement component, said engagement securing the membrane to the frame.

[0038] The apparatus may further comprise a secondary expandable frame being in a selected position in the ventricle of the heart when expanded, the secondary frame being secured to the membrane and connected to the membrane-side engagement component thereby interconnecting the membrane to the membrane-side engagement component.

[0039] The anchor may be connected to the at least one frame.

[0040] The frame-side engagement component may be connected to the primary

frame at a central portion of the primary frame.

[0041] The membrane-side engagement component may be connected to the secondary frame at a central portion of the secondary frame.

[0042] The apparatus may further comprise an active anchor being connected to the frame-side engagement component such that a first movement of the frame-side engagement component causes the active anchor to enter the myocardium and a second movement of the frame-side engagement component causes the active anchor to withdraw from the myocardium.

[0043] The apparatus may further comprise a passive anchor being connected to at least one of the frames such that the passive anchor enters the myocardium when the frame expands.

[0044] The invention further provides an apparatus for improving cardiac function comprising a flexible liner, a membrane secured to the liner, the membrane and the liner jointly forming a cardiac device being moveable between a collapsed and an expanded state, in the collapsed state the cardiac device being insertable into a ventricle of a heart. In the expanded state the cardiac device being in a selected position in the ventricle, the liner covering a wall in the ventricle and the membrane separating the ventricle into two volumes, and an anchor connected to the cardiac device, the anchor being insertable into a myocardium of the heart to secure the cardiac device to the myocardium in the selected position in the ventricle.

[0045] The flexible liner may comprise a plurality of lengths of strands being connected at endpoints thereof.

[0046] The apparatus may further comprise a frame secured to the cardiac device and connected to the anchor thereby interconnecting the cardiac device and the anchor.

[0047] The apparatus may further comprise a frame-side engagement component being connected to the cardiac device and an active anchor being connected to the frame-side engagement component such that a first movement of the frame-side engagement component causes the active anchor to enter the myocardium and a second movement of the frame-side engagement component causes the active anchor to withdraw from the myocardium.

[0048] The apparatus may further comprise a passive anchor being connected to the cardiac device such that the passive anchor enters the myocardium when the cardiac device expands.

[0049] The invention further provides an apparatus for improving cardiac function comprising an expandable frame being in a selected position in a ventricle of the heart and having an outer edge when expanded, the outer edge defining a non-planar cross-section of an inner wall of a ventricle and an anchor connected to the frame, the anchor being insertable into the myocardium of the heart to secure the frame to the myocardium in the selected position in the ventricle.

[0050] The apparatus may further comprise a membrane being secured to a frame, the membrane separating the ventricle into two volumes.

[0051] The frame may have a vertical axis and the outer edge may have a diameter, the diameter intersecting the vertical axis at an angle other than 90 degrees.

[0052] The invention further provides an apparatus for improving cardiac function comprising an anchor being insertable into a myocardium of a heart to secure the anchor to the myocardium within a ventricle of the heart, an anchor-side engagement component being secured to the anchor, an expandable frame being in a selected position in the ventricle when expanded, and a frame-side engagement component

being secured to the frame, the frame-side engagement component being engageable with the anchor-side engagement component, said engagement securing the frame to the anchor in the selected position in the ventricle.

[0053] The apparatus may further comprise a membrane being secured to the frame.

[0054] A first movement of the anchor-side engagement component may cause the anchor to enter a myocardium and a second movement of the anchor-side engagement component may cause the anchor to withdraw from the myocardium.

[0055] A first movement of the frame-side engagement component may cause the frame-side engagement component to engage the anchor-side engagement component and a second movement of the frame-side engagement component may cause the frame-side engagement component to disengage the anchor-side engagement component.

[0056] Said engagement may release the frame from the anchor.

[0057] The invention further provides an apparatus for improving cardiac function comprising a flexible body, a membrane connected to the flexible body, the membrane and flexible body jointly forming a cardiac device being movable between a collapsed and an expanded state, in the collapsed state the cardiac device being insertable into a ventricle of the heart, in the expanded state the cardiac device being in a selected position in the ventricle, and an anchor connected to the cardiac device, the anchor being insertable into the myocardium of the heart to secure the cardiac device to the myocardium in the selected position of the ventricle.

[0058] The apparatus may further comprise a frame having a distal end, the membrane may be secured to the frame, and the body may have proximal and distal ends, the proximal end of the body being secured to the distal end of the frame, and

the distal end of the body being connected to the anchor.

[0059] The body may be cylindrical with a diameter of between 0.5 mm and 6 mm and a height of between 1 mm and 100 mm.

[0060] The cardiac device may have a vertical axis.

[0061] The body may have a proximal opening at the proximal end, a distal opening at the distal end, and a passageway therethrough connecting the proximal and distal openings.

[0062] The body may be able to bend between 0 and 120 degrees from the vertical axis.

[0063] The invention further provides a device for improving cardiac function comprising a collapsible and expandable frame having first and second portions, the frame being insertable into a ventricle of a heart when collapsed, when expanded the frame being in a selected position in the ventricle and the second portion of the frame covering a wall in the ventricle, a membrane secured to the frame such that the membrane divides the ventricle into at least two volumes when the frame is expanded, the frame and the membrane jointly forming a cardiac device, and an anchor connected to the cardiac device, the anchor being insertable into a myocardium of the heart to secure the cardiac device in the selected position in the ventricle.

[0064] The frame may further comprise a plurality of segments, each segment having an inner and outer portion being connected at ends thereof, the outer portions being at an angle to the inner portions.

[0065] The membrane may be secured to the inner and outer portions of the segments.

[0066] The device may further comprise a plurality of anchors being connected to

at least one segment such that when the frame expands the anchors enter the myocardium in a first direction, and when the frame collapses the anchors withdraw from the myocardium in a second direction approximately 180 degrees from the first direction.

[0067] Some of the anchors may extend in a third direction.

[0068] The invention further provides a system for improving cardiac function comprising a collapsible and expandable frame, when collapsed the frame being insertable into a selected position in a ventricle of the heart through an opening in the heart having a small cross-dimension, when expanded in the selected position, the frame having a large cross-dimension, and an anchor connected to the frame, being insertable into a myocardium of the heart to secure the frame to the myocardium in the selected position.

[0069] The opening may be an incision in the myocardium.

[0070] The anchor may further comprise a plurality of strands woven through the myocardium such that the opening is closed.

[0071] The invention further provides a system for improving cardiac function comprising an external actuator, an elongate manipulator having a tube suitable to be inserted into a ventricle of a heart to a selected position and a deployment member positioned therein slidably between a first and second position, the deployment member having proximal and distal ends, the distal end being within the tube when the deployment member is in the first position and out of the tube when the deployment member is in the second position, the deployment member being connected to the external actuator at the proximal end thereof, a deployment-side engagement component on the distal end of the deployment member, a frame-side engagement component being engageable with the deployment-side engagement

component, said engagement securing the deployment-side engagement component to the frame-side engagement component such that a movement of the external actuator causes the engagement components to disengage, said disengagement releasing the deployment-side engagement component from the frame-side engagement component, a frame being connected to the frame-side engagement component, the frame being moveable between a collapsed and an expanded state, the frame being connected to the deployment member in the collapsed state with a small cross-dimension when the deployment member is in the first position and the frame is within the tube, the frame being shaped such that when the deployment member is moved to the second position and the frame exits the tube, the frame expands to the expanded state with a large cross-dimension and when the deployment member is moved back to the first position, the frame collapses to the collapsed state as the frame enters the tube, and an anchor connected to the frame being insertable into a myocardium of the heart to secure the frame to the myocardium of the heart, such that the deployment mechanism can be removed from the heart, the anchor entering the myocardium in a first direction when the frame expands and withdrawing from the myocardium in a second direction when the frame collapses, said withdrawal releasing the frame from the myocardium.

[0072] The external manipulator may further comprise an anchor deployment knob and a detachment knob.

[0073] The deployment member may further comprise an anchor shaft having proximal and distal ends and a detachment shaft having proximal and distal ends, the proximal end of the anchor shaft being connected to the anchor deployment knob, the proximal end of the detachment shaft being connected to the detachment knob.

[0074] The deployment-side engagement component may further comprise a deployment-side anchor formation connected to the distal end of the anchor shaft and a deployment-side detachment formation connected to the distal end of the detachment shaft.

[0075] The frame-side engagement component may further comprise a frame-side anchor formation being connected to the anchor and a frame-side detachment formation on the frame, the frame-side anchor formation being engageable with the deployment-side anchor formation, the frame-side detachment formation being engageable with the deployment-side detachment formation, a first movement of the detachment knob causing the deployment-side detachment formation to engage the frame-side detachment formation, said engagement securing the frame to the deployment member, a first movement of the anchor deployment knob causing the anchor to enter the myocardium and a second movement of the anchor deployment knob causing the anchor to withdraw from the myocardium, a second movement of the detachment knob causing the deployment-side detachment formation to disengage the frame-side detachment formation, said disengagement releasing the frame from the deployment member.

[0076] The anchor shaft and the detachment shaft may be coaxial.

[0077] The anchor shaft may be an inner torque shaft and the detachment shaft may be an outer torque shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The invention is further described by way of examples with reference to the accompanying drawings, wherein:

[0007] Figure 1 is an exploded side view of a system for improving cardiac function, according to one embodiment of the invention, including a cardiac device

and a deployment system, the deployment system including a deployment mechanism and a catheter tube;

[0008] Figure 2 is a cross-sectional side view of a handle of the deployment mechanism and a proximal end of a deployment member of the deployment mechanism;

[0009] Figure 3A is cross-sectional side view of a distal end of the deployment member including a key and a detachment screw;

[0010] Figure 3B is a cross-sectional end view on 3B-3B in Figure 3A of the deployment member;

[0011] Figure 3C is a cross-sectional end view on 3C-3C in Figure 3A of the key;

[0012] Figure 4 is a perspective view of the cardiac device including a hub, a frame, and a stem thereof;

[0013] Figure 5A is a side view of the cardiac device;

[0014] Figure 5B is a perspective view of the hub;

[0015] Figure 5C is a top plan view of the hub;

[0016] Figure 6 is a cross-sectional side view of the stem;

[0017] Figure 7A is a side view of the distal end of the deployment member connected to the cardiac device;

[0018] Figure 7B is a cross-sectional view on 7B-7B in Figure 7A of the cardiac device;

[0019] Figure 8 is a cross-sectional side view of the cardiac device with the key connected thereto;

[0020] Figure 9 is a side view of the system of Figure 1 with the components integrated with and connected to one another;

[0021] Figure 10A is a view similar to Figure 9 with the cardiac device partially

retracted into the catheter;

[0022] Figure 10B is a cross-sectional side view of a portion of Figure 10A;

[0023] Figure 11A is a side view of the system with the cardiac device further retracted;

[0024] Figure 11B is a cross-sectional side view of a portion of Figure 11A;

[0025] Figure 12A is a side view of the system with the cardiac device fully retracted;

[0026] Figure 12B is a cross-sectional side view of a portion of Figure 12A;

[0027] Figure 13A is a cross-sectional side view of a human heart with the catheter inserted therein;

[0028] Figures 13B-13K are cross-sectional side views of the human heart illustrating installation (Figures 13B – 13E), removal (Figures 13E – 13H), and subsequent final installation (Figures 13I – 13K) of the cardiac device;

[0029] Figure 14A is a perspective view of a cardiac device according to another embodiment of the invention;

[0030] Figure 14B is a cross-sectional side view of the human heart with the cardiac device of Figure 14A installed;

[0031] Figure 15A is a perspective view of a cardiac device according to a further embodiment on the invention;

[0032] Figure 15B is a cross-sectional top plan view of the cardiac device on 15B-15B in Figure 15A;

[0033] Figure 15C is a cross-sectional side view of the human heart with the cardiac device of Figure 15A installed;

[0034] Figure 16A is a perspective view of a cardiac device according to a further embodiment of the invention;

[0035] Figure 16B is a cross-sectional side view of the cardiac device of Figure 16A;

[0036] Figure 16C is a cross-sectional side view of the human heart with the cardiac device of Figure 16A installed;

[0037] Figure 17A is a perspective view of a cardiac device according to a further embodiment of the invention;

[0038] Figure 17B is a cross-sectional side view of the human heart with the cardiac device of Figure 17A installed;

[0039] Figure 18A is a perspective view of a cardiac device according to a further embodiment of the invention;

[0040] Figure 18B is a cross-sectional side view of the human heart with the cardiac device of Figure 18A installed;

[0041] Figure 19A is a perspective view of a cardiac device according to a further embodiment of the invention;

[0042] Figure 19B is a cross-sectional side view of the human heart while the cardiac device of Figure 19A is being installed;

[0043] Figure 19C is a cross-sectional side view of the human heart while the cardiac device of Figure 19A is being installed;

[0044] Figure 19D is a cross-sectional side view of a human heart with the cardiac device of Figure 19A installed;

[0045] Figure 20A is a perspective view of a frame of a cardiac device according to another embodiment of the invention;

[0046] Figure 20B is a perspective view of a stem of the cardiac device of Figure 20A;

[0047] Figure 20C is a cross-sectional side view of the cardiac device of Figure

20A and Figure 20B with the stem attached to the frame;

[0048] Figure 20D is a cross-sectional side view of a distal end of a deployment member of a deployment mechanism according to another embodiment of the invention;

[0049] Figure 20E is a cross-sectional side view of the distal end of the deployment member of a deployment mechanism of Figure 20D; and

[0050] Figures 20F – 20I are cross sectional side views of a human heart illustrating installation of the cardiac device of Figure 20A and Figure 20B.

DETAILED DESCRIPTION OF THE INVENTION

[0051] Figure 1 illustrates a system 30 for improving cardiac function according to one embodiment of the invention. The system 30 includes a deployment system 32 and a cardiac device 34. The deployment system 32 includes a deployment mechanism 36 and a catheter tube 38.

[0052] The catheter tube 38 is cylindrical with a length 40 of 110 cm and a diameter 42 of 5 mm. The catheter tube 38 has a circular cross-section and is made of a soft, flexible material.

[0053] The deployment mechanism 36 includes a handle 44 and a deployment member 46. The handle 44 has a proximal end 48 and a distal end 50. The deployment member 46 has a proximal end 52 and a distal end 54. The proximal end 52 of the deployment member 46 is secured to the distal end 50 of the handle 44.

[0054] Figures 2, 3A, 3B, and 3C illustrate the deployment mechanism 36 in more detail. Figure 2 illustrates the handle 44 while Figures 3A, 3B, and 3C illustrate components at the distal end 54 of the deployment member 46. The components of the deployment mechanism 36 are primarily circular with center lines on a common

axis.

[0055] The handle 44 is made of molded plastic and includes a main body 56, an anchor knob 58, an end piece 60, a proximal rotating hemostatic valve 62, a fluid line 64, a distal rotating hemostatic valve 66, and a detachment knob 68. The main body 56 is cylindrical with a length 70 of 80 mm and a diameter 72 of 25 mm. The main body 56 has a proximal 74 and a distal 76 opening at the respective ends thereof and a passageway 78 therethrough connecting the openings with an inner diameter 80 of 4 mm.

[0056] The proximal rotating hemostatic valve 62 is a cylindrical body with a passageway 82 therethrough having an inner diameter 84 of 4 mm, a locking hypo tube 86 within the passageway, a tapered outer end 88, and a raised formation 90 at a central portion thereof. The proximal rotating hemostatic valve 62 is rotationally secured to the proximal opening 74 of the handle 44. The locking hypo tube 86 is a cylindrical body secured within the passageway 82 of the proximal rotating hemostatic valve 62.

[0057] The end piece 60 is a cylindrical body with a passageway 92 therethrough connecting a proximal 94 and distal 96 opening at respective ends and having an inner diameter 98 of 5 mm. Raised formations 100 stand proud from respective central and outer portions of the end piece. A cylindrical end piece pin 102 is connected to an inner surface and extends across the inner diameter 98 of the passageway 92. The end piece pin 102 is made of stainless steel and has a length of 5 mm and a diameter of 2 mm. The distal opening 96 of the end piece 60 mates with the tapered outer end 88 of the proximal rotating hemostatic valve 62.

[0058] The anchor knob 58 is a cap-shaped body with a length 104 of 20 mm and an outer diameter 106 of 10 mm. The anchor knob 58 has a small opening 108 at a

proximal end 110 with a diameter 112 of 4 mm and a large opening 114 at a distal end 116 with a diameter 118 of 6 mm. The anchor knob 58 fits over and is secured to both the end piece 60 and the proximal rotating hemostatic valve 62.

[0059] The fluid line 64 enters the handle 44 through the small opening 108 of the anchor knob 58 and is secured to the proximal opening 94 of the end piece 60. The fluid line 64 has an outer diameter 120 of 5 mm.

[0060] The distal rotating hemostatic valve 66 is a cylindrical body with a passageway 122 therethrough having a proximal inner diameter 124 of 4 mm at a proximal end 126 thereof and a distal inner diameter 128 of 5 mm at a distal end 130 thereof. The distal end 130 is tapered, and a raised formation 132 lies at a central portion thereof. The distal rotating hemostatic valve 66 is rotationally secured to the distal opening 76 of the main body 56.

[0061] The detachment knob 68 is a cap-shaped body with a length 134 of 20 mm and an outer diameter 136 of 20 mm. The detachment knob 68 has a large opening 138 at a proximal end 140 with a diameter 142 of 8 mm and a small opening 144 at a distal end 146 with a diameter 148 of 5 mm. The detachment knob 68 fits over and is secured to the distal rotating hemostatic valve 66.

[0062] Referring to Figures 3A – 3C, the deployment member 46 includes an inner torque shaft 150 and an outer torque shaft 152. The inner torque shaft has a diameter 154 of 2 mm and is made of surgical stainless steel. The outer torque shaft is a hollow, cylindrical body with an inner diameter 156 of 3 mm and an outer diameter 158 of 5 mm. The outer torque shaft 152 is a polymer.

[0063] Referring again to Figure 2, the inner torque shaft 150 passes through the detachment knob 68, through the distal rotating hemostatic valve 66, into and out of the passageway 78 of the main body 56, through the proximal rotating hemostatic

valve 62, and into the end piece 60. The proximal end of the inner torque shaft 150 is wrapped around the end piece pin 102, reenters the proximal rotating hemostatic valve 62, and is attached to the locking hypo tube 86 within the proximal rotating hemostatic valve 62.

[0064] The outer torque shaft 152 is coaxial with and surrounds the inner torque shaft 150. A proximal end 160 of the outer torque shaft 152 passes into the distal hemostatic valve 66 and is secured thereto.

[0065] The distal end 54 of the deployment member 46 includes a key 162, a detachment screw 164, and a securing mechanism 166. A distal end 168 of the inner torque shaft 150 extends out of a distal end 170 of the outer torque shaft 152, and the key 162 is attached thereto. The key 162 is rectangular with a length 171 of 7 mm and a height 172 of 3 mm. The key 162 has a semi-circular cross section with a radius 174 of 1.5 mm. The detachment screw 164 is attached to the distal end 170 of the outer torque shaft 152, extends to a length 176 of 7 mm, and has a diameter 178 of 5 mm.

[0066] The securing mechanism 166 includes an inner component 180 and an outer component 182. The inner component 180 is a raised cylindrical portion coaxial with and on the inner torque shaft 150. The inner component 180 stands proud of the inner torque shaft 150 by 0.5 mm. The outer component 182 is a hollow, cylindrical body secured to an inner surface of the outer torque shaft 152 and has proximal and distal openings with diameters of 2.25 mm so that the inner torque shaft 150 cannot move axially relative to the outer torque shaft 152.

[0067] Figures 4, 5A – 5C, and 6 illustrate the cardiac device 34 in more detail. The cardiac device 34 includes a frame 184 and a stem 186, or flexible body, and has a vertical axis 188.

[0068] The frame 184 includes a frame hub 190, a plurality of main segments 192, and a membrane 194. The hub 190 is a ring-shaped body with an outer surface 196 with a diameter 198 of 5 mm, an inner surface 200 with a diameter 202 of 4 mm, a thickness 204 of 3 mm, and a pin 206 extending off-center across the inner surface 200 creating a smaller and a larger gap. The pin 206 has a length of 3.5 mm and a diameter of 1 mm and is located in a plane 208. The frame 184 has a diameter 209 of approximately 25 mm, however, other embodiments may have diameters of between 10 mm and 100 mm. The entire hub 190 is made of nickel titanium.

[0069] The main segments 192 include first portions, or central segments, 210, second portions, or outer segments, 212, and passive anchors 214. The first portions 210 are connected to the hub 190 at a central portion of the outer surface 196 and extend radially from the hub 190 at an angle away from the plane 208 of the pin 206 to a length 216 of 8 mm. The second portions 212 of the segments 192 are connected to ends of the first portions 210 and further extend radially from the hub 190 but at an angle towards the plane 208. The second portions 212 each have a length 218 of 5 mm. The passive anchors 214 are formed at an end of each of the second portions 212. The passive anchors 214 have sharp ends that point slightly radially from the hub 190. The segments 192 are made from nickel titanium, which after a prescribed thermal process, allows for the segments 192 to hold their shape as illustrated, for example, in Figure 4. The entire frame 184, or just portions of the frame 184, may also be made of stainless steel.

[0070] The membrane 194 is stretched over the first 210 and second 212 portions of the segments 192 to give the frame 184 a disk like shape. The membrane 194 is made of expanded Poly Tetra Fuoro Ethylene (ePTFE) and has a thickness of 0.08 mm. Other embodiments may use a mesh membrane.

[0071] Figure 6 illustrates the stem 186 unattached to the frame 184. The stem 186 is a hollow, cylindrical body with a passageway 220 therethrough connecting a proximal 222 and a distal 224 opening. The stem 186 has a height 226 of 9 mm, an outer diameter 228 of 5 mm, and an inner diameter 230 of 4 mm. The stem 186 includes a first hub 232 and a second hub 234, both similar to the hub 190 on the frame 184. The second hub 234 is secured within the passageway 220 near the distal opening 224 of the stem 186. The first hub 232 is loose within the stem 186 so that it may move, and has an active anchor 236, in the shape of a screw, attached. The active anchor 236 spirals from the first hub 232 to engage with the pin on the second hub 234. The active anchor 236 has a diameter 238 of 3.5 mm and a length 240 of 7 mm.

[0072] The stem 186 is made of Poly Tetra Fuoro Ethylene (PTFE) and is thus expandable and flexible. Referring again to Figure 4, the stem 186 can be compressed or stretched by 30% of its length and can be bent from the vertical axis 188 of the device 34 by 120 degrees in any direction. The first hub 232, second hub 234, and active anchor 236 are made of nickel titanium. In other embodiments, the hubs may be made of stainless steel.

[0073] Figures 7A, 7B, 8, and 9 illustrate the system 30 with the stem 186 connected to the cardiac device 34 and the cardiac device 34 connected to the deployment mechanism 36. The stem 186 is fused to the frame hub 190 thus securing the stem 186 to the device 34.

[0074] In use, the deployment member 46 is inserted through the catheter tube 38 so that the distal end 54 of the deployment member 46 exits the distal end of the tube 38. As shown in Figures 7A and 7B, the deployment member 46 connects to the cardiac device 34 such that the key 162 engages the hub 190 of the frame 184

by passing through the larger gap in the hub 190. As shown in Figure 8, the key 162 passes through the hub 190 of the frame 184 to engage with the first hub 232 of the stem 186, but does not reach the second hub 234. Once the key 162 is fully inserted into the stem 186, the detachment knob 68 is turned which rotates the outer torque shaft 152 and thus the detachment screw 164 because the detachment screw 164 is attached to the outer torque shaft 152. The rotation thereof causes the detachment screw 164 to engage with the pin 206 of the frame hub 190, securing the cardiac device 34 to the deployment mechanism 36.

[0075] Rotation of the anchor knob 58 in a first direction causes the active anchor 236 to be deployed from the distal opening 224 of the stem 186 because the anchor knob 58 is connected to the inner torque shaft 150 which, in turn, is connected to the key 162. Rotation of the key 162 causes the first hub 232 to rotate and because the active anchor 236 is connected to the first hub 232 and engaged with the pin of the second hub 234, the active anchor 236 "twists" out of the distal opening 224 of the stem while the first hub 232 is pulled toward the distal opening 224. Rotation of the anchor knob 58 in a second direction causes the active anchor 236 to reenter the distal opening 224 of the stem 186.

[0076] As illustrated in Figures 10A and 10B, the distal end 54 of the deployment member 46 is then pulled into the distal end of the catheter tube 38. As a proximal section of the frame 184 enters the catheter tube 38, the first portions 210 of the segments 192 begin to collapse towards the stem 186. The segments 192 collapse, or fold, against a spring force that is created by the resilient nature of the nickel titanium material from which they are made. At the same time, the second portions 212 fan out radially away from the hub 190.

[0077] As illustrated in Figures 11A and 11B, by the time a distal section of the

frame 184 and the second portions 212 of the segments 192 begin to enter the tube 38, the second portions 212 have been bent back to collapse towards the stem 186 similarly to the first portions 210.

[0078] Figures 12A and 12B illustrate the system 30 with the cardiac device 34 completely contained within the catheter tube 38.

[0079] Figures 13A – 13J illustrate a human heart 242 while the cardiac device 34 is being deployed. The heart 242 contains a right ventricle 244 and a left ventricle 246 with papillary muscles 248 and an akinetic portion 250 with an apex 252. The distal end of the catheter 38 has been inserted through the aorta and aortic valve into the left ventricle 246 to a selected position where the cardiac device 34 can be deployed. The catheter tube 38 is then partially pulled off of the cardiac device 34 exposing the stem 186.

[0080] The active anchor 236 is then deployed by rotating the anchor knob 58 in a first direction. The active anchor 236 penetrates the myocardium of the heart 242 to secure the cardiac device 34 in the selected position at the apex 252 of the akinetic portion 250 of the left ventricle 246.

[0081] The catheter 38 is then completely removed from the distal end 54 of the deployment member 46, exposing the cardiac device 34. As the cardiac device 34 expands, due to the resilient nature of the segments 192 and the pre-set shape of the frame 184, the passive anchors 214 on the segments 192 penetrate the myocardium in a first direction. The membrane 194 seals a portion of the ventricle 246 and separates the ventricle 246 into two volumes.

[0082] If the cardiac device 34 has not been properly positioned, or if it is of the wrong size or shape for the particular heart, the device 34 may be repositioned or completely removed from the heart 242.

[0083] Rotation of the anchor knob 58 in a second direction will cause the active anchor 236 to be removed from the apex 252 of the akinetic portion 250 of the left ventricle 246 thus releasing the cardiac device 34 from the heart 242. The distal end 54 of the deployment member 46 may be retracted into the catheter 38 to once again fold the cardiac device 34 into the position shown in Figure 12B, from where it can again be deployed. The passive anchors 214 are removed from the myocardium in a second direction which is approximately 180 degrees from the first direction so that minimal damage is done to the myocardium.

[0084] However, if the cardiac device 34 has been properly positioned and is of the proper size and shape, rotation of the detachment knob 68 in a second direction will cause the detachment screw 164 at the distal end 170 of the outer torque shaft 152 to disengage the pin 206 in the frame hub 190, thus releasing the deployment member 46 from the cardiac device 34 to allow removal of the deployment member 46 from the heart 242. Figure 13K illustrates the heart 242 with the cardiac device 34 installed and the deployment mechanism 36 removed from the heart 242.

[0085] One advantage of this system is that the shape of the frame 184 allows the device 34 to be retrieved as long as the deployment member 46 is still connected to the device 34. When the device 34 is retrieved, the passive anchors 214 withdraw from the myocardium in a direction that is approximately 180 degrees from, or opposite, the first direction to minimize the amount of damage done to the myocardium. The device 34 also provides support for the akinetic region 250, minimizes the bulging of the akinetic region 250, and reduces stress on the working parts of the myocardium. A further advantage is that the ePTFE membrane 194 is biocompatible, has a non-thrombogenic surface, promotes healing, and accelerates endothelialization.

[0086] Figure 14A illustrates a cardiac device 254 according to another embodiment of the invention. The cardiac device includes a hub 256, a frame 258, and a membrane 260. The hub 256 lies at a central portion of the frame 258 and an active anchor 262 is connected to the hub 256 and extends downwards therefrom. The frame 258 includes a plurality of segments 264 which extend radially and upwardly from the hub 256. A sharp passive anchor 266 lies at the end of each of the segments 264. The membrane 260 is stretched between the segments 264 to form a cone-shaped body.

[0087] Figure 14B illustrates a human heart with the cardiac device 254 of Figure 14A having been secured to an akinetic portion thereof.

[0088] Figure 15A and Figure 15B illustrate a cardiac device 268 according to a further embodiment of the invention. The cardiac device includes a hub 270, a frame 272, and membrane 274. The hub 270 lies at a central portion of the frame 272 and an active anchor 276 extends downwardly from the hub 270. The frame 272 includes a plurality of segments 278 which extend radially and upwardly from the hub 270. The segments 278 are of different lengths such that an outer edge 280 of the cardiac device 268 is not planar. The device 268 has a vertical axis 282 which intersects a diameter 284 across the outer edge 280 of the device 268 at an angle other than 90 degrees. A sharp passive anchor 286 lies at the end of each of the segments 278. The membrane 274 is stretched between the segments 278 to form a cone-shaped body. Referring specifically to Figure 15B, a cross-section perpendicular to the vertical axis 282 of the device 268 is circular.

[0089] Figure 15C illustrates a human heart with the cardiac device 268 of Figure 15A having been secured to an akinetic portion thereof. The outer edge 280 of the cardiac device 268 defines a non-planar cross-section of an inner surface of the left

ventricle.

[0090] A further advantage of this embodiment is that the device 268 can be sized and shaped for use on a wider variety of akinetic portions in left ventricles.

[0091] Figure 16A and Figure 16B illustrate a cardiac device 288 according to a further embodiment of the invention. The cardiac device 288 includes a first hub 290, a first frame 292, a second hub 294, a second frame 296, a first membrane 298, and a second membrane 300. The first hub 290 is attached to a central portion of the first frame 292. A plurality of segments 302 extend radially from and upwards from the first hub 290. The first membrane 298 is occlusive and made of a thrombogenic material and stretched between the segments 302 to form a first cone-shaped body. A plurality of fibers 304 extend radially from an outer edge 306 of the first cone-shaped body. An active anchor 308 extends down from the first hub 290.

[0092] The second frame 296 includes a plurality of segments 310 extending radially and upwardly from the second hub 294 and end in sharp passive anchors 312. An attachment screw 314, similar to the detachment screw 164, extends downwards from the second hub 294. Referring specifically to Figure 16B, the attachment screw 314 is rotated so that it engages a pin 316 within the first hub 290, similarly to the frame hub 190 already described, to secure the second frame 296 to the first frame 292. The second membrane 300 is made of ePTFE and stretched between the segments 310 to form a second cone-shaped body.

[0093] Figure 16C illustrates a human heart with the cardiac device 288 of Figure 16A secured to an akinetic portion thereof. The fibers 304 on the outer edge 306 of the first frame 292 are interacting with an inner surface of the left ventricle to seal off the volume below the outer edge 306 of the first frame 292. The passive anchors 312 on the ends of the segments 310 of the second frame 296 have penetrated the

myocardium to hold the device 288 in place.

[0094] A further advantage of this embodiment is that the fibers 304 of the first membrane 298 interface with trabeculae and further block the flow of blood into the apex of the akinetic portion.

[0095] Figure 17A illustrates a cardiac device 318 according to a further embodiment of the invention. The cardiac device 318 includes proximal 320 and distal 322 hubs, a frame 324, a stem 326, a braided structure 328, and a membrane 330. The frame 324 includes a plurality of segments 332 extending radially and upwards from the distal hub 322, and the membrane 330 is stretched between the segments 332 to form a cone-like body having an outer edge 334. Two extra segments 336 extend across the outer edge 334 of the cone-like body and are connected to and support the proximal hub 320 above the distal hub 322. The stem 326, including an active anchor 338, extends downwards from the distal hub 322. The braided structure 328 is made of nickel titanium and is connected to a distal end of the stem 326 into the ends of the segments 332. The segments 332 end in sharp passive anchors 340. The braided structure 328 may also be made of a biodegradable material or a polymer.

[0096] Figure 17B illustrates a human heart with the cardiac device 318 of Figure 17A having been secured to an akinetic portion thereof. The braided structure 328 presses against an inner surface of the left ventricle.

[0097] A further advantage of this embodiment is that the braided structure 328 allows the device to "nestle" into position before the active anchor 338 is deployed to secure the device 318 in place. Further advantages are that the braided structure 328 adds structural stability to the device 318 and the nickel titanium of the braided structure 328 provides a mechanism for containing thrombi in the static chamber.

[0098] Figure 18A illustrates a cardiac device 342 according to a further embodiment of the invention. The cardiac device 342 includes proximal 344 and distal 346 hubs, a frame 348, and a membrane 350. A plurality segments 352, having first 354 and second 356 portions, extend upwardly and radially from the distal hub 346 in a curved fashion and are bent and extend inwards to meet at the proximal hub 344. The membrane 350 is stretched across the segments 352 to form a semi-circular or basket-shaped body. Sharp passive anchors 358 extend from the segments 352 between the first 354 and second 356 portions.

[0099] Some of the passive anchors 358 extend in a primarily axial direction with a small radial component, and some of the passive anchors 358 extend in a primarily radial direction with a small axial component. Other embodiments may have both types of passive anchors on a single segment.

[00100] Figure 18B illustrates a human heart with the cardiac device 342 of Figure 18A having been installed into an akinetic portion thereof. The segments 352 are pressed against the myocardium because the device is slightly oversized.

[00101] A further advantage of this embodiment is that because of the size of the device 342 and shape of the segments 352, the passive anchors 358 are assisted in penetrating the myocardium. A further advantage is that because of the shape of the frame 348, the device 342 can be retrieved from the left ventricle as long as the device 34 is still attached to the deployment member 46. A further advantage is that because the entire frame 348 is covered with the membrane 350, the flow of blood to the apex of the akinetic portion is even further blocked.

[00102] Figure 19A illustrates a cardiac device 360 according to a further embodiment of the invention. The cardiac device 360 includes a frame 362 and a stem 364. The frame 362 includes a plurality of segments 366 which extend

upwardly and radially from the stem 364 and end in a plurality of sharp passive anchors 368. The stem 364 extends downwards from the frame 362 and includes two suture strands 370 at a distal end thereof.

[00103] Figures 19B, 19C, and 19D illustrate the installation of the cardiac device 360 of Figure 16. While a high pressure is maintained in the left ventricle the catheter tube 38 is inserted through the outer wall into the left ventricle with the cardiac device 360 inserted in the distal end thereof. The catheter 38 is removed from the cardiac device 360, and the cardiac device 360 expands such that the passive anchors 368 are inserted into the inner surface of the left ventricle. The catheter 38 is then completely removed and the sutures 370 are used to close the insertion made by the catheter 38 and to secure the cardiac device 360 to the akinetic portion.

[00104] Figures 20A, 20B, and 20C illustrate a cardiac device 372 according to a further embodiment of the invention. The cardiac device 372 includes a frame hub 374, a frame 376, a membrane 378, and a stem 380. The frame hub 374 lies at a central portion of the frame 376. The frame 376 includes a plurality of segments 382 which extend radially and upwardly from the frame hub 374. A sharp passive anchor 384 lies at the end of each of the segments 382. The membrane 378 is stretched between the segments 382 to form a cone-shaped body. Before installation, the stem 380 is unattached to the frame hub 374 and includes a proximal hub 386, an anchor hub 388, and a distal hub 390, each having a pin 392 extending across an inner surface thereof, similar to that of the frame hub 190. The proximal 386 and distal 390 hubs are frictionally held near their respective ends in the stem 380, and the anchor hub 388 is loose within the stem 380 so that it may move. An active anchor 394 extends downwards from the anchor hub 388.

[00105] Figures 20D and 20E illustrate another embodiment of a distal end 396 of a deployment member 398. The distal end 396 includes a detachment piece 400 and an attachment hub 402. The detachment piece 400 has been added to the distal end of the outer torque shaft 152. The detachment piece 400 is a ring shaped body made of stainless steel with a length of 3 mm and an inner diameter suitable to frictionally hold the attachment hub 402, which is similar to the frame hub 190. An attachment screw 404, similar to the detachment screw 164, extends downwards from the attachment hub 402. Referring specifically to Figure 20E, forces along the length of the deployment member 398 will, by design, cause the attachment hub 402 to become dislodged from the detachment piece 400.

[00106] Figures 20F – 20H illustrate installation of the cardiac device 372 of Figures 20A and 20B into a human heart. In this embodiment, the deployment member used does not include the securing mechanism 166 so that the inner and outer torque shafts may move axially relative to one another.

[00107] Before the device 372 and stem 380 are inserted into a heart, the inner torque shaft is passed through the frame hub 374, the proximal hub 386, and the anchor hub 388, and the outer torque shaft is positioned and rotated so that the attachment screw 404 engages both the pins 392 of the frame 374 and proximal 386 hubs, securing the cardiac device 372 to the stem 380. The device 372 and the stem 380 are then retracted into the catheter 38 and steered into a left ventricle. The stem 380 is secured to an apex of an akinetic portion of a left ventricle of the heart by rotating the inner torque shaft, causing the active anchor 394 to penetrate the myocardium. Rotation of the outer torque shaft then causes the attachment screw 404 to disengage the pin 392 of the proximal hub 386, and the device 372 is released from the stem 380. However, the inner torque shaft remains engaged with

the hubs in the stem 380.

[00108] If it is determined that the stem 380 has been properly positioned, the cardiac device 372, secured to the outer torque shaft, is pushed over the inner torque shaft to meet the stem 380. The outer torque shaft is again rotated so that the attachment screw 404 reengages the pin 392 on the proximal hub 386 of the stem, thus re-securing the stem 380 to the frame 376. The deployment member 398 is then forcibly pulled away from the device 372 and the detachment piece 400 releases the attachment screw 404. Figure 20I illustrates the human heart with the cardiac device 372 of Figures 20A and 20B installed.

[00109] While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative and not restrictive of the current invention, and that this invention is not restricted to the specific constructions and arrangements shown and described since modifications may occur to those ordinarily skilled in the art.

WHAT IS CLAIMED:

1. A system for treating a patient's heart to improve cardiac function, comprising:
 - a. at least one external actuator;
 - b. an elongate manipulator connected to the external actuator;
 - c. a manipulator-side engagement component on a distal end of the elongate manipulator;
 - d. a collapsible and expandable reinforced membrane;
 - e. a engagement component on the reinforced membrane releasably engageable with the manipulator-side engagement component so that the external actuator can steer the reinforced membrane when collapsed into a ventricle of a heart whereafter the reinforced membrane is expanded; and
 - f. at least one anchor connected to the reinforced membrane, movement of the external actuator allowing for (i) insertion of the anchor into heart tissue defining in part the ventricle, (ii) subsequent withdrawal of the anchor out of the heart tissue, (iii) subsequent re-insertion of the anchor into the heart tissue, the insertion securing the reinforced membrane to the heart tissue in a selected position, and (iv) subsequent disengagement of the manipulator-side engagement component from the engagement component of the reinforced membrane, the disengagement releasing the reinforced membrane from the elongate manipulator.
2. The system of claim 1, wherein the reinforced membrane has a frame that has a collapsed configuration suitable for being inserted into the ventricle of the

heart through a tubular passage of a delivery catheter and expanded configuration when deployed in the ventricle.

3. The system of claim 2, wherein the frame includes a plurality of segments extending from a central portion of the frame.
4. The system of claim 2, wherein the frame is formed at least in part of nickel titanium.
5. The system of claim 2, wherein the frame is formed at least in part of stainless steel.
6. The system of claim 3, wherein the membrane is stretched between the plurality of segments of the frame when the membrane partitions the ventricle into a main productive portion and a secondary non-productive portion.
7. The system of claim 6, wherein the membrane is formed at least in part of ePTFE.
8. The system of claim 6, wherein the membrane is in the form of a mesh.
9. The system of claim 6, wherein the plurality of segments include first portions and second portions connected at ends thereof such that the second portions are at an angle to the first portions.
10. The system of claim 9, wherein the first portions of the frame are proximal portions and the second portions are distal portions.
11. The system of claim 2, wherein the frame has a diameter between about 10 mm and about 100 mm when expanded.

12. The system of claim 2, including at least one active anchor and at least one passive anchor.

13. The system of claim 12, wherein the insertion of the passive anchor is in a first direction and the withdrawal of the passive anchor is in a second direction, the second direction being substantially 180 degrees from the first direction.

14. The system of claim 13, including a first passive anchor extending in the first direction and a second passive anchor extending in a third direction.

15. The system of claim 13, wherein the active and passive anchors have sharp ends that penetrate heart tissue defining at least in part the patient's ventricle.

16. The system of claim 15, including a tubular passage with a distal end suitable to be inserted into the heart tissue defining the patient's ventricle.

17. The system of claim 16, wherein the elongate manipulator includes a frame member with a proximal and a distal end and an anchor member with a proximal and a distal end, the frame and anchor members being moveable through the tubular passage.

18. The system of claim 17, wherein the frame has a stem with an anchoring formation on the distal end thereof.

19. The system of claim 18, wherein the stem component has an actuator element configured to be engaged by the distal end of the drive mechanism and an anchor element on the distal end thereof.

20. The system of claim 19, wherein distal movement of the drive mechanism causes the anchor element to be inserted into heart tissue defining at

least in part the patient's heart chamber to secure the frame within the patient's heart chamber.

21. An apparatus for improving cardiac function of a patient's heart, comprising:
 - a. a frame which includes
 - i. a plurality of central frame segments surrounding a central axis, the central segments having first and second ends, the first ends being pivotally connected to a central portion of the frame; and
 - ii. a plurality of outer frame segments having first and second ends, the first ends being pivotally secured to the second ends of the central segments;
 - b. a membrane secured to the frame such that movement of the second ends of the central segments away from the central axis causes the membrane to unfold, the unfolding of the membrane causing the outer segments to pivot relative to their respective central segments away from the central axis and movement of the second ends of the central segments toward the central axis causes the membrane to fold, the folding of the membrane causing the outer segments to pivot relative to their respective central segments toward the central axis; and
 - c. an anchor connected to the frame which is insertable into heart tissue of the patient's heart chamber to secure the cardiac device within the patient's heart chamber.
22. The apparatus of claim 21, wherein the frame includes at least three central segments and at least three outer segments.

23. The apparatus of claim 22, wherein the membrane is stretched between the central and the outer segments.
24. The apparatus of claim 23, wherein the anchor is secured directly to the frame.
25. An apparatus for improving cardiac function, comprising:
 - a. a frame;
 - b. a membrane, having an inner surface, secured to the frame, the membrane and the frame jointly forming a cardiac device being moveable between a collapsed and an expanded state, in the collapsed state at least a portion of the inner surface of the membrane facing a vertical axis of the cardiac device and the cardiac device being insertable into a ventricle of a heart, in the expanded state the portion of the inner surface of the membrane facing away from a vertical axis and being in contact with a patient's heart tissue and the cardiac device being in a selected position in the ventricle; and
 - c. an anchor connected to the cardiac device[[,]] which is insertable into the patient's heart tissue to secure the cardiac device in the selected position in the ventricle.
26. The apparatus of claim 25, wherein the cardiac device collapses toward the vertical axis and expands away from the vertical axis.
27. The apparatus of claim 26, wherein the membrane folds toward the vertical axis when the cardiac device collapses and unfolds away from the vertical axis when the cardiac device expands.

28. The apparatus of claim 27, wherein the frame formed of an alloy selected from the group consisting of nickel titanium and stainless steel.

29. The apparatus of claim 28, wherein the membrane is formed of at least in part of ePTFE.

30. The apparatus of claim 29, wherein the anchor has a sharp end.

31. An apparatus for treating a patient's heart to improve the patient's cardiac function, comprising:

- a frame being expandable in a selected position to a pre-set shape in a ventricle of the patient's heart;
- a formation on the frame; and
- an anchoring device which has an anchor element and which is configured to be engaged with and rotatable relative to the formation on the frame to rotate the anchor element relative to the frame, causing the anchor element to be inserted into heart tissue defining at least in part the ventricle to secure the frame in a selected position within the ventricle.

32. The apparatus of claim 31, where the anchoring device engages the formation such that a first rotation of the anchoring device causes the anchor element to move away from the frame and a second rotation of the anchoring device causes the anchor element to move towards the frame.

33. The apparatus of claim 32, wherein the formation is a pin.

34. The apparatus of claim 33, wherein the anchor is a screw.

35. An apparatus for improving a patient's cardiac function, comprising:
 - a. at least a primary expandable frame being in a selected position in a ventricle of a heart when expanded;
 - b. an anchor connected to the frame, the anchor being insertable into a patient's heart tissue to secure the primary frame within the ventricle;
 - c. a frame-side engagement component connected to the primary frame;
 - d. a membrane; and
 - e. a membrane-side engagement component being engageable with the frame-side engagement component, the engagement securing the membrane to the frame.

36. The apparatus of claim 35, including a secondary expandable frame being in a selected position in the ventricle of the heart when expanded, the secondary frame being secured to the membrane and connected to the membrane-side engagement component thereby interconnecting the membrane to the membrane side engagement component.

37. The apparatus of claim 36, wherein the anchor is connected to the at least one of the frames.

38. The apparatus of claim 37, wherein the primary frame has a central portion and the frame-side engagement component is connected to the primary frame at the central portion of the primary frame.

39. The apparatus of claim 38, wherein the secondary frame has a central portion and the membrane-side engagement component is connected to the secondary frame at the central portion of the secondary frame.

40. The apparatus of claim 39, including an active anchor being connected to the frame-side engagement component such that a first movement of the frame-side engagement component causes the active anchor to enter the patient's heart tissue and a second movement of the frame-side engagement component causes the active anchor to withdraw from the patient's heart tissue.

41. The apparatus of claim 40, including a passive anchor being connected to at least one of the frames such that the passive anchor enters the patient's heart tissue when the frame expands.

42. An apparatus for improving cardiac function, comprising:

- a flexible liner;
- a membrane secured to the liner, the membrane and the liner jointly forming a cardiac device being moveable between a collapsed and an expanded state, in the collapsed state the cardiac device being insertable into a ventricle of a heart, in the expanded state the cardiac device being in a selected position in the ventricle, the liner covering a wall in the ventricle and the membrane separating the ventricle into a main productive portion and a secondary non-productive portion; and
- an anchor connected to the cardiac device, the anchor being insertable into a patient's heart tissue of the heart to secure the cardiac device to the patient's heart tissue in the selected position in the ventricle.

43. The apparatus of claim 42, wherein the flexible liner includes a plurality of lengths of strand being connected at endpoints thereof.

44. The apparatus of claim 43, including a frame secured to the cardiac device and connected to the anchor thereby interconnecting the cardiac device and the anchor.

45. The apparatus of claim 44, including a frame-side engagement component being connected to the cardiac device and an active anchor being connected to the frame-side engagement component such that a first movement of the frame-side engagement component causes the active anchor to enter the patient's heart tissue and a second movement of the frame-side engagement component causes the active anchor to withdraw from the patient's heart tissue.

46. The apparatus of claim 43, including a passive anchor being connected to the cardiac device such that the passive anchor enters the patient's heart tissue when the cardiac device expands.

47. An apparatus for improving cardiac function, comprising:

- a. an expandable frame-reinforced membrane being in a selected position in a ventricle of a heart and having an outer edge when expanded, the outer edge defining a non-planar cross section of an inner wall of the ventricle; and
- b. an anchor connected to the frame which is configured to secure the frame-reinforced membrane to the patient's heart tissue in the selected position in the ventricle.

48. The apparatus of claim 47, wherein the frame-reinforced membrane separates the ventricle into a main productive portion and a secondary non-productive portion.

49. The apparatus of claim 48, wherein the frame-reinforced membrane has a vertical axis and the outer edge of the frame-reinforced membrane has a diameter, the diameter intersecting the vertical axis at an angle other than 90 degrees.

50. An apparatus for improving cardiac function, comprising:

- a. an anchor being insertable into ventricular tissue of a patient's heart to secure the anchor to the within a ventricle of the heart;
- b. an anchor-side engagement component being secured to the anchor;
- c. an expandable frame-reinforced membrane being in a selected position in the ventricle when expanded; and
- d. a frame-side engagement component being secured to the frame-reinforced membrane and being engageable with the anchor-side engagement component, the engagement securing the frame-reinforced membrane to the anchor in the selected position in the ventricle.

51. The apparatus of claim 50, wherein the membrane is secured to the frame.

52. The apparatus of claim 51, wherein a first movement of the anchor-side engagement component causes the anchor to enter the patient's heart tissue and a second movement of the anchor-side engagement component causes the anchor to withdraw from the patient's heart tissue.

53. The apparatus of claim 52, wherein a first movement of the frame-side engagement component causes the frame-side engagement component to engage the anchor-side engagement component and a second movement of the frame-side

engagement component causes the frame-side engagement component to disengage the anchor-side engagement formation.

54. The apparatus of claim 53, wherein the disengagement releases the frame-reinforced membrane from the anchor.

55. An apparatus for improving a patient's cardiac function, comprising:

- a. a flexible body;
- b. a reinforced membrane connected to the flexible body, the membrane and the flexible body jointly forming a cardiac device being moveable between a collapsed and an expanded state, in the collapsed state the cardiac device being insertable into a ventricle of the patient's heart, in the expanded state the cardiac device being in a selected position in the ventricle; and
- c. an anchor connected to the cardiac device, the anchor being insertable into the patient's heart tissue to secure the cardiac device to the patient's heart tissue in the selected position in the ventricle.

56. The apparatus of claim 55, wherein the membrane is reinforced by a frame having a distal section and wherein the membrane is secured to the frame and the body has a proximal and a distal end, the proximal end of the body being secured to the distal section of the frame and the distal end of the body being connected to the anchor.

57. The apparatus of claim 56, wherein the body is cylindrical with a diameter of between about 0.5 mm and 6 mm and a height of between about 1 mm and 100 mm.

58. The apparatus of claim 57, wherein the cardiac device has a vertical axis.

59. The apparatus of claim 57, wherein the body has a proximal opening at the proximal end, a distal opening at the distal end, and a passageway therethrough connecting the proximal and distal openings.

60. The apparatus of claim 59, wherein the body can bend at an angle of up to about 120 degrees from the vertical axis.

61. A device for improving a patient's cardiac function, comprising:

- a. a collapsible and expandable frame having first and second portions, the frame being insertable into a ventricle of the patient's heart when collapsed, when expanded the frame being in a selected position in the ventricle and the second portion of the frame covering a wall in the ventricle;
- b. a membrane secured to the frame such that the membrane divides the ventricle into at least a main productive portion and a non-productive portion when the frame is expanded, the frame and the membrane jointly forming a cardiac device; and
- c. an anchor connected to the cardiac device, the anchor being insertable into the patient's heart tissue to secure the cardiac device in the selected position in the ventricle.

62. The device of claim 61, wherein the frame includes a plurality of segments, each segment having an inner and outer portion connected at ends thereof, the outer portions being at an angle to the inner portions.

63. The device of claim 62, wherein the membrane is secured to the inner and outer portions of the segments.

64. The device of claim 63, including a plurality of anchors being connected to at least one segment such that when the frame expands the anchors enter the patient's heart tissue in a first direction, and when the frame folds the anchors withdraw from the patient's heart tissue in a second direction approximately 180 degrees from the first direction.

65. The device of claim 64, wherein some of the anchors extend in a third direction.

66. A system for improving a patient's cardiac function, comprising:

- a collapsible and expandable frame, when collapsed the frame being insertable into a selected position in a ventricle of the patient's heart through an opening in the heart having a small cross-dimension, when expanded in the selected position the frame having a large cross-dimension; and
- an anchor connected to the frame, being insertable into a myocardium of the heart to secure the frame to the myocardium in the selected position.

67. The system of claim 66, wherein the opening is an incision in a wall of the patient's heart.

68. The system of claim 67, wherein the anchor includes a plurality of strands woven through the myocardium such that the opening is closed.

69. A system for improving cardiac function, comprising:

- a. an external actuator;
- b. an elongate manipulator having a tube suitable to be inserted into a ventricle of a heart to a selected position and a deployment member positioned therein slidably between a first and second position, the deployment member having proximal and distal ends, the distal end being within the tube when the deployment member is in the first position and out of the tube when the deployment member is in the second position, the deployment member being connected to the external actuator at the proximal end thereof;
- c. a deployment-side engagement component on the distal end of the deployment member;
- d. a frame-side engagement component being engageable with the deployment-side engagement component, the engagement securing the deployment-side engagement component to the frame-side engagement component such that a movement of the external actuator causes the engagement components to disengage, the disengagement releasing deployment-side engagement component from the frame-side engagement component;
- e. a frame being connected to the frame-side engagement component, the frame being moveable between a collapsed and an expanded state, the frame being connected to the deployment member in the collapsed state with a small cross-dimension when the deployment member is in the first position and the frame is within the tube, the frame being shaped such that when the deployment member is moved to the second position and the frame exits the tube, the frame expands

to the expanded state with a large cross-dimension and when the deployment member is moved back to the first position, the frame collapses to the collapsed state as the frame enters the tube; and

f. an anchor connected to the frame being insertable into a myocardium of the heart to secure the frame to the myocardium of the heart such that the deployment mechanism can be removed from the heart, the anchor entering the myocardium in a first direction when the frame expands and withdrawing from the myocardium in a second direction when the frame collapses, the withdrawal releasing the frame from the myocardium.

70. The apparatus of claim 69, wherein the external manipulator includes an anchor deployment knob and a detachment knob.

71. The apparatus of claim 70, wherein the deployment member includes an anchor shaft having proximal and distal ends and a detachment shaft having proximal and distal ends, the proximal end of the anchor shaft being connected to the anchor deployment knob, the proximal end of the detachment shaft being connected to the detachment knob.

72. The apparatus of claim 71, wherein the deployment side engagement component includes a deployment-side anchor formation connected to the distal end of the anchor shaft and a deployment-side detachment formation connected to the distal end of the detachment shaft.

73. The apparatus of claim 72, wherein the frame-side engagement component includes a frame-side anchor formation being connected to the anchor

and a frame-side detachment formation on the frame, the frame-side anchor formation being engageable with the deployment-side anchor formation, the frame-side detachment formation being engageable with the deployment-side detachment formation, a first movement of the detachment knob causing the deployment-side detachment formation to engage the frame-side detachment formation, the engagement securing the frame to the deployment member, a first movement of the anchor deployment knob causing the anchor to enter the myocardium and a second movement of the anchor deployment knob causing the anchor to withdraw from the myocardium, a second movement of the detachment knob causing the deployment-side detachment formation to disengage the frame-side detachment formation, the disengagement releasing the frame from the deployment member.

74. The apparatus of claim 73, wherein the anchor shaft and the detachment shaft are coaxial.

75. The apparatus of claim 74, wherein the anchor shaft is an inner torque shaft and the detachment shaft is an outer torque shaft.

76. A system for partitioning a patient's heart chamber in the treatment of congestive heart failure, comprising:

- a. a deployable partitioning device having
 - i. a reinforced membrane component which has a contracted configuration and an expanded configuration and which has at least one anchoring member to secure the reinforced membrane component within the patient's heart chamber,

- ii. a driving hub component secured to a central portion of the reinforced membrane, and
- iii. a stem component which extends distally from the reinforced membrane and which has a proximal end secured to the driving hub and a distal end configured to engage a portion of the patient's heart wall; and

b. a deploying system to place the deployable partitioning device within a patient's heart chamber to separate the heart chamber into a productive portion and a non-productive portion and which has a manipulatable handle, an elongated drive mechanism that is secured by its proximal portion to the handle and which has an engaging member on its distal end for engaging the driving hub on the reinforced membrane.

77. The system of claim 76 wherein the reinforced membrane comprises a radially expandable frame formed in part by a plurality of ribs.

78. The system of claim 77 wherein the ribs have first ends which are secured to the hub and second ends which are free.

79. The system of claim 78 wherein the ribs are configured so that the free second ends expand radially away from a longitudinal axis and contract toward the longitudinal axis.

80. The system of claim 79 wherein the ribs of the frame form a proximal face and the membrane is secured to the proximal face.

81. The system of claim 76 wherein the reinforced membrane has a plurality of anchors about a peripheral edge of the reinforced membrane which are configured to penetrate into the patient's heart tissue to position the reinforced membrane within the patient's heart chamber.

82. The system of claim 81, wherein the anchors around the reinforced membrane have sharp ends to facilitate penetration into the patient's heart tissue.

83. The system of claim 80, wherein the membrane folds toward the longitudinal axis when the reinforced membrane collapses and unfolds away from the longitudinal axis when the reinforced membrane expands.

84. The system of claim 77, wherein the ribs of the frame are formed of at least one alloy selected from the group consisting of nickel titanium alloy and stainless steel.

85. The system of claim 76, wherein the membrane is formed at least in part of ePTFE.

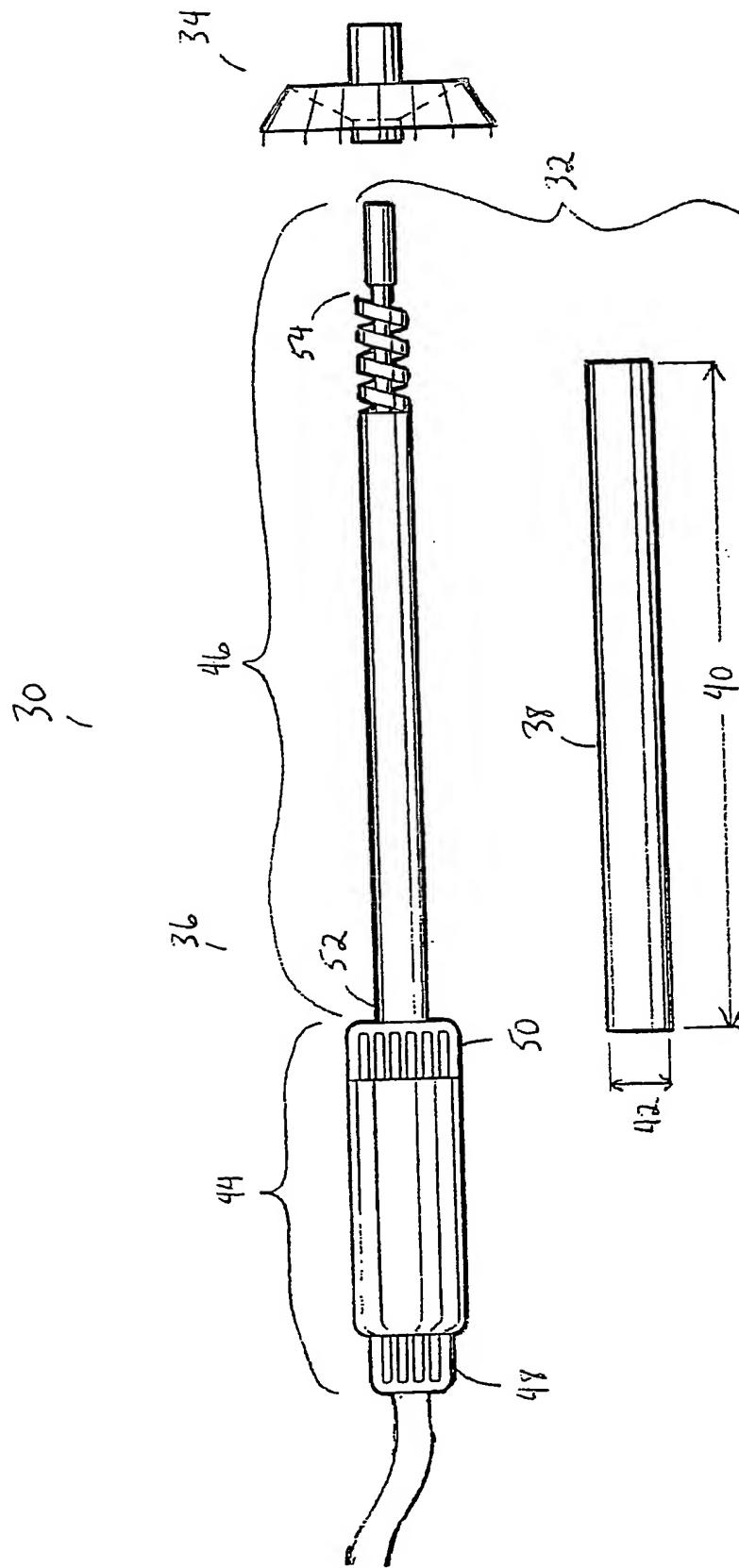
86. The system of claim 76 wherein the stem has an inner lumen extending to an open end.

87. The system of claim 76 wherein the distal end of the stem has a tissue penetrating anchor member.

88. The system of claim 87 wherein the tissue penetrating anchor member at the distal end of the stem includes a floating collar which is slidably disposed within the inner lumen of the stem and which has a distally extending helical coil with a tissue penetrating tip secured to the collar.

89. The system of claim 88 wherein the engaging member on the distal end of the elongated drive mechanism is configured to engage the floating collar and to rotate the collar to drive the tissue penetrating tip of the attached helical coil into the patient's heart tissue.

90. The system of claim 20 wherein a second movement of the drive mechanism causes the partitioning device to be discharged from the deploying system.



F

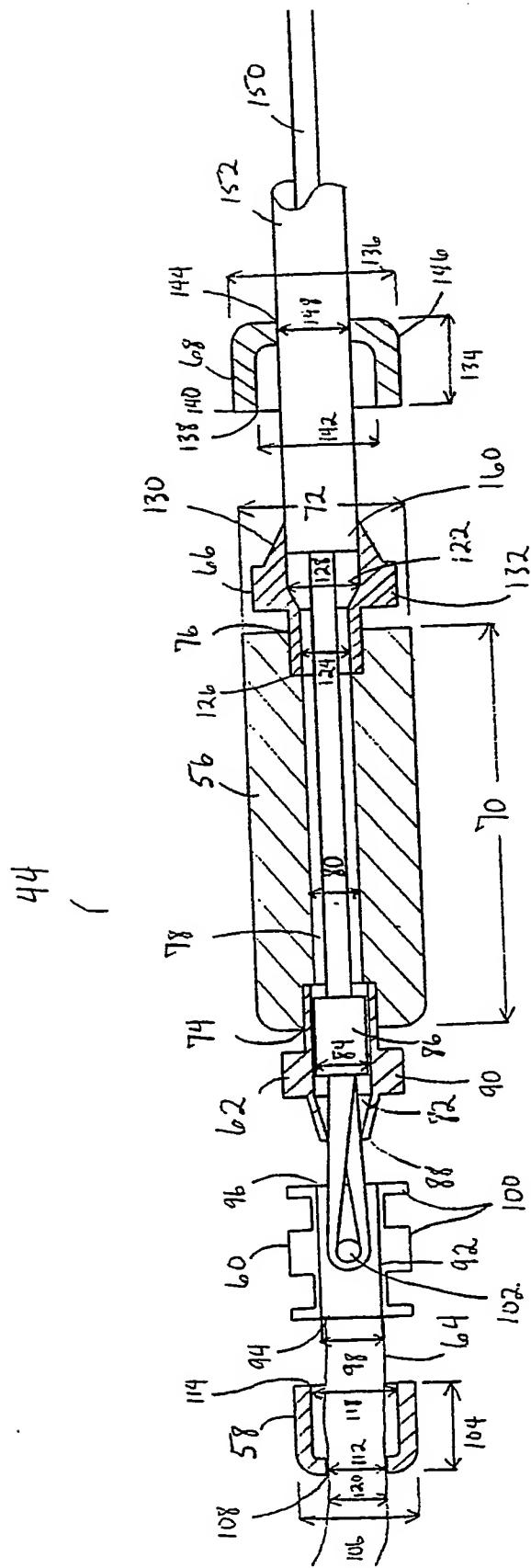


Fig. 2

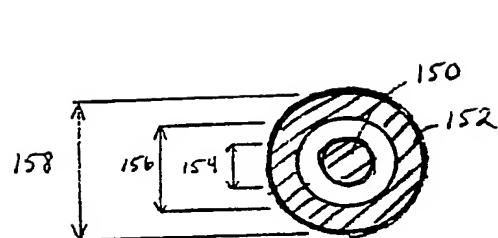
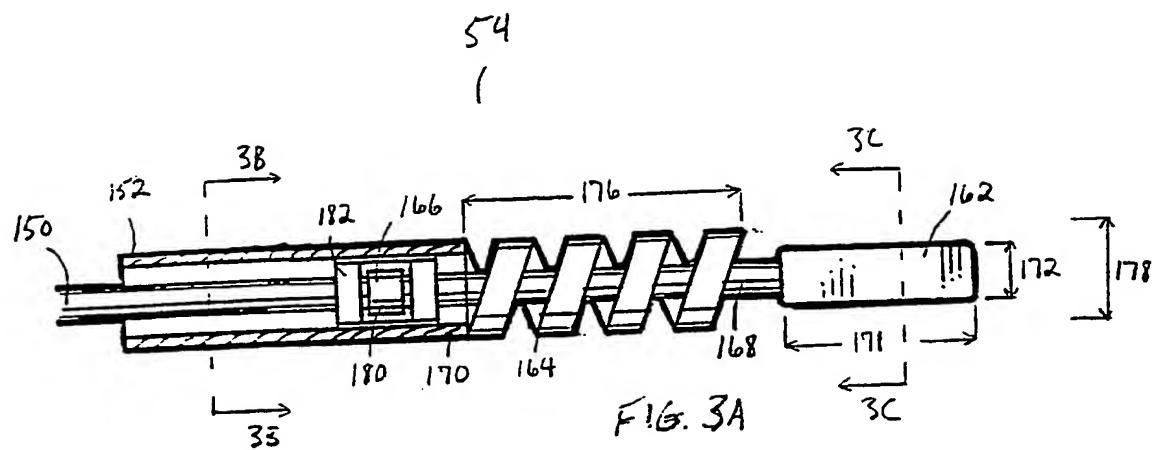


FIG. 3B



FIG. 3C

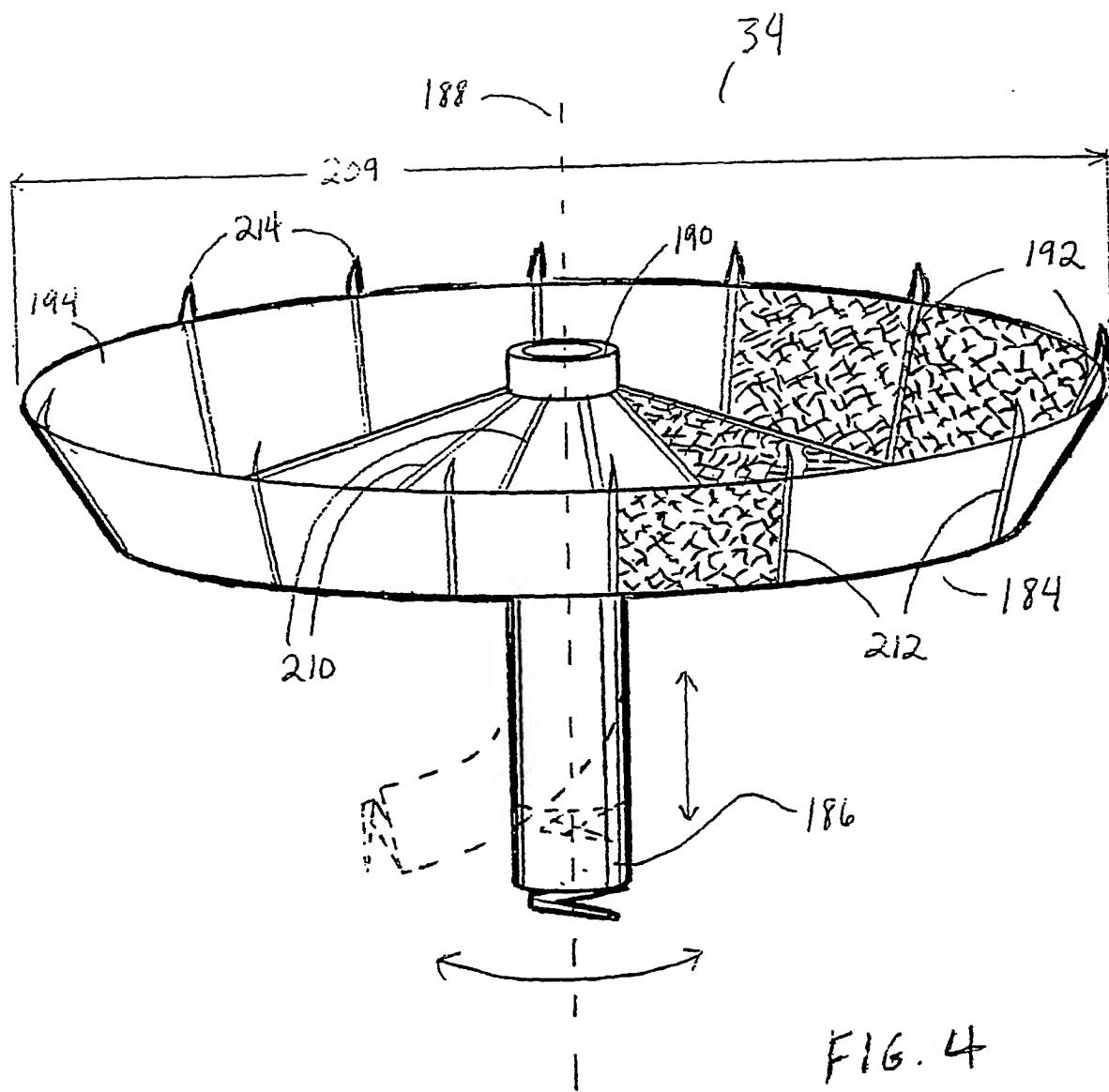
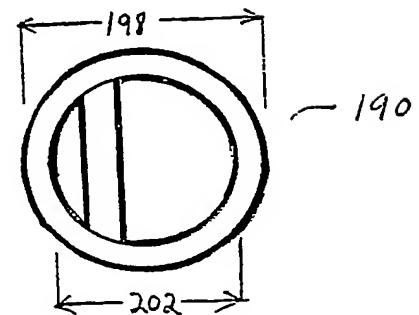
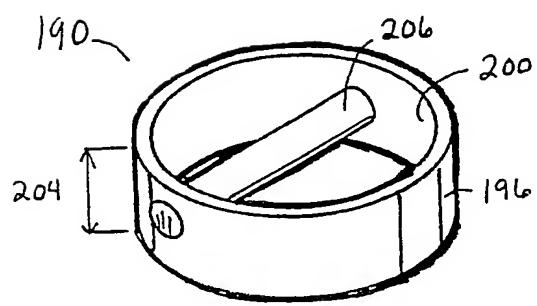
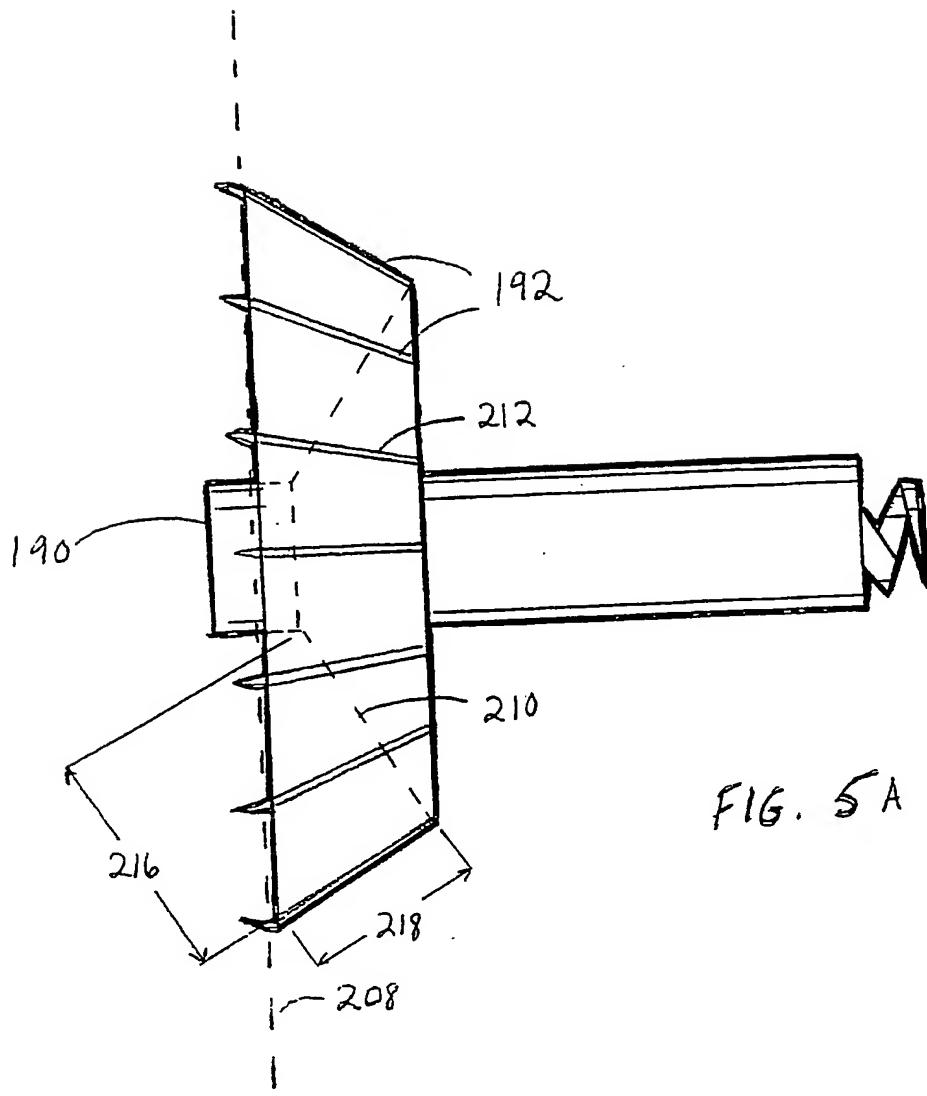
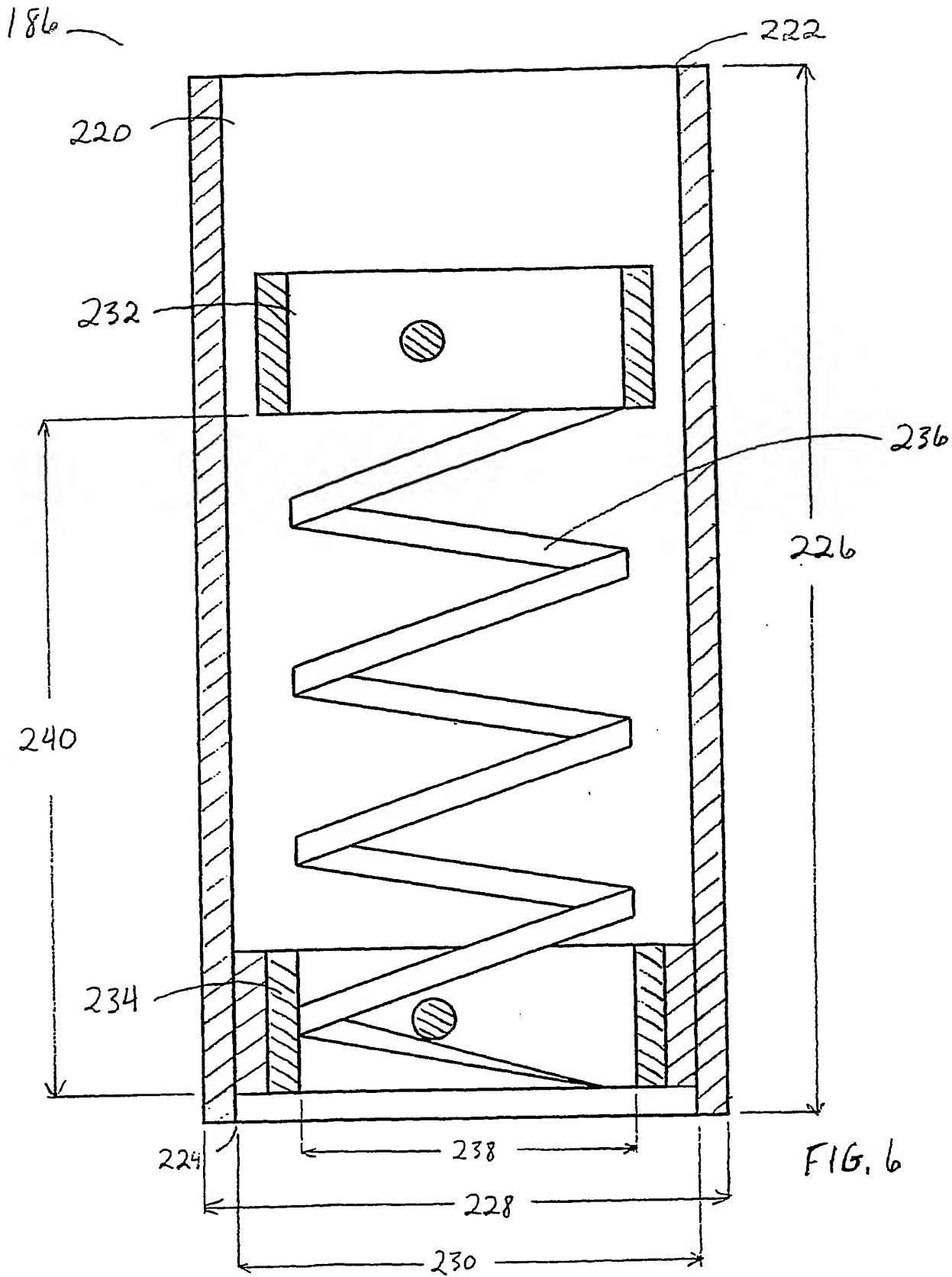


FIG. 4





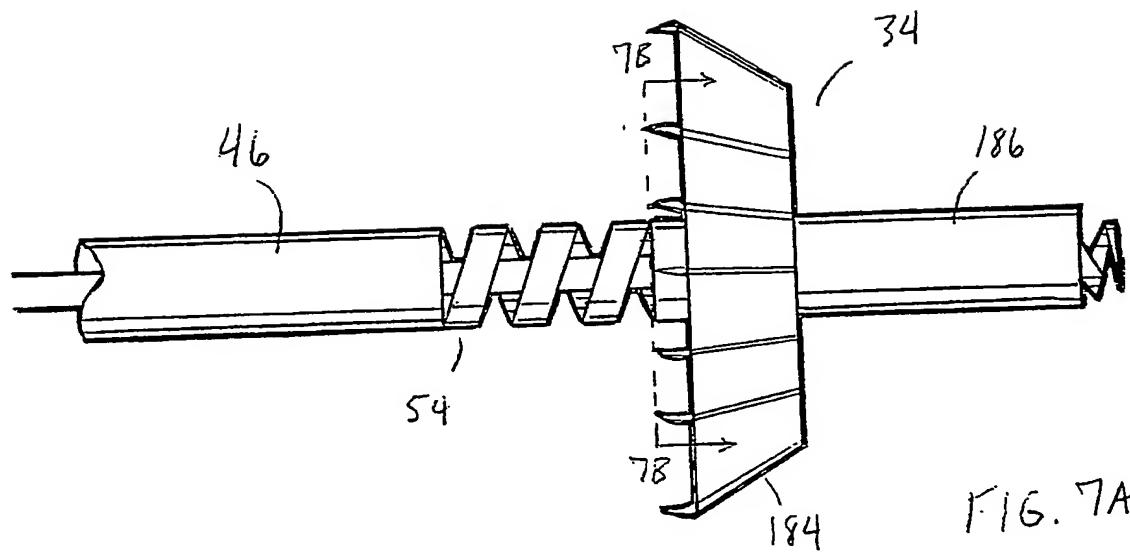


FIG. 7A

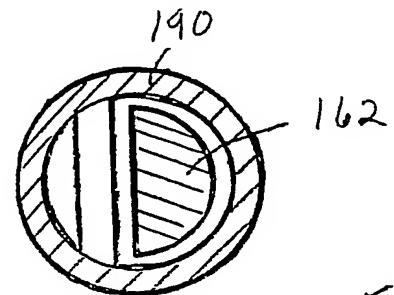
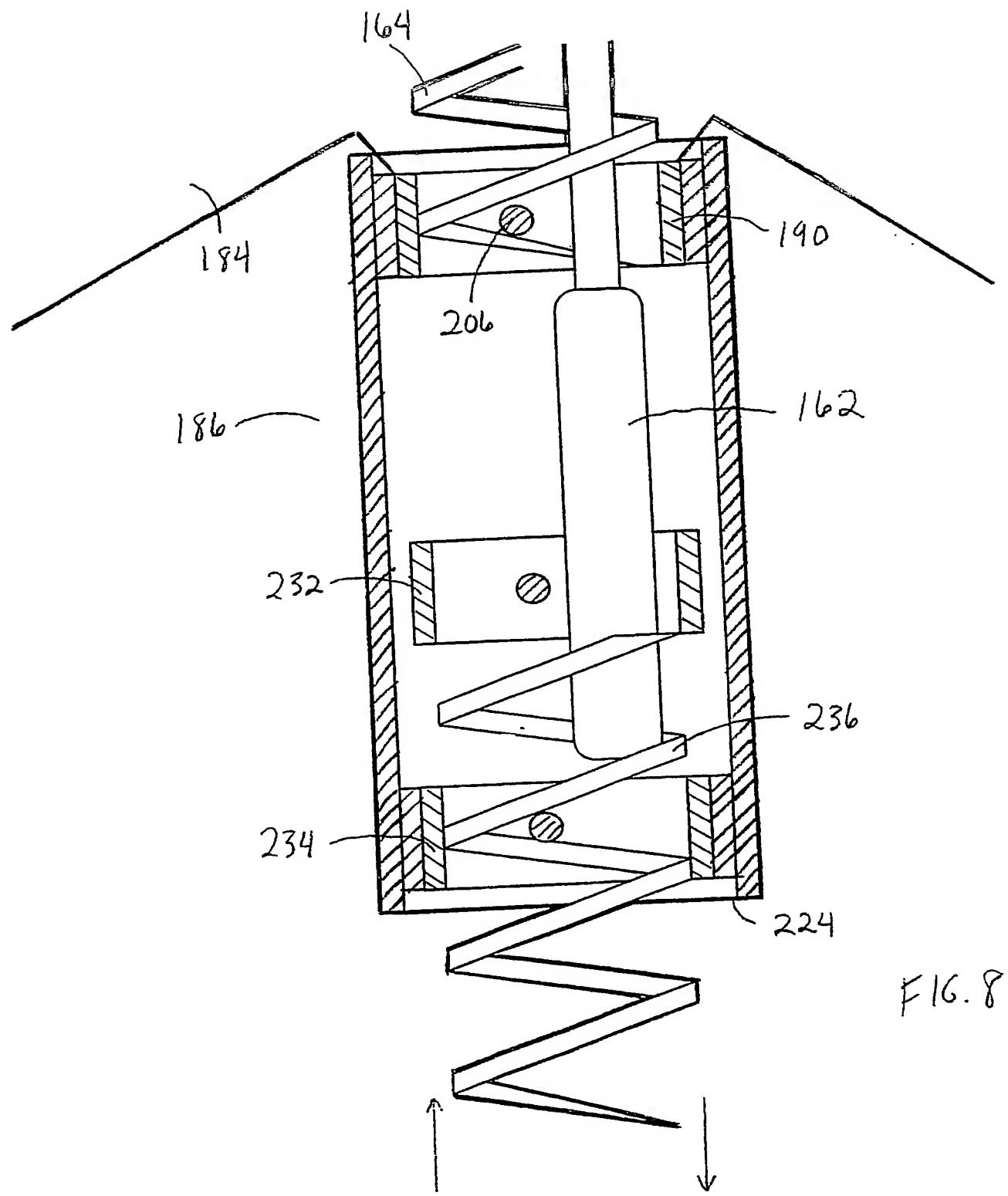


FIG. 7B



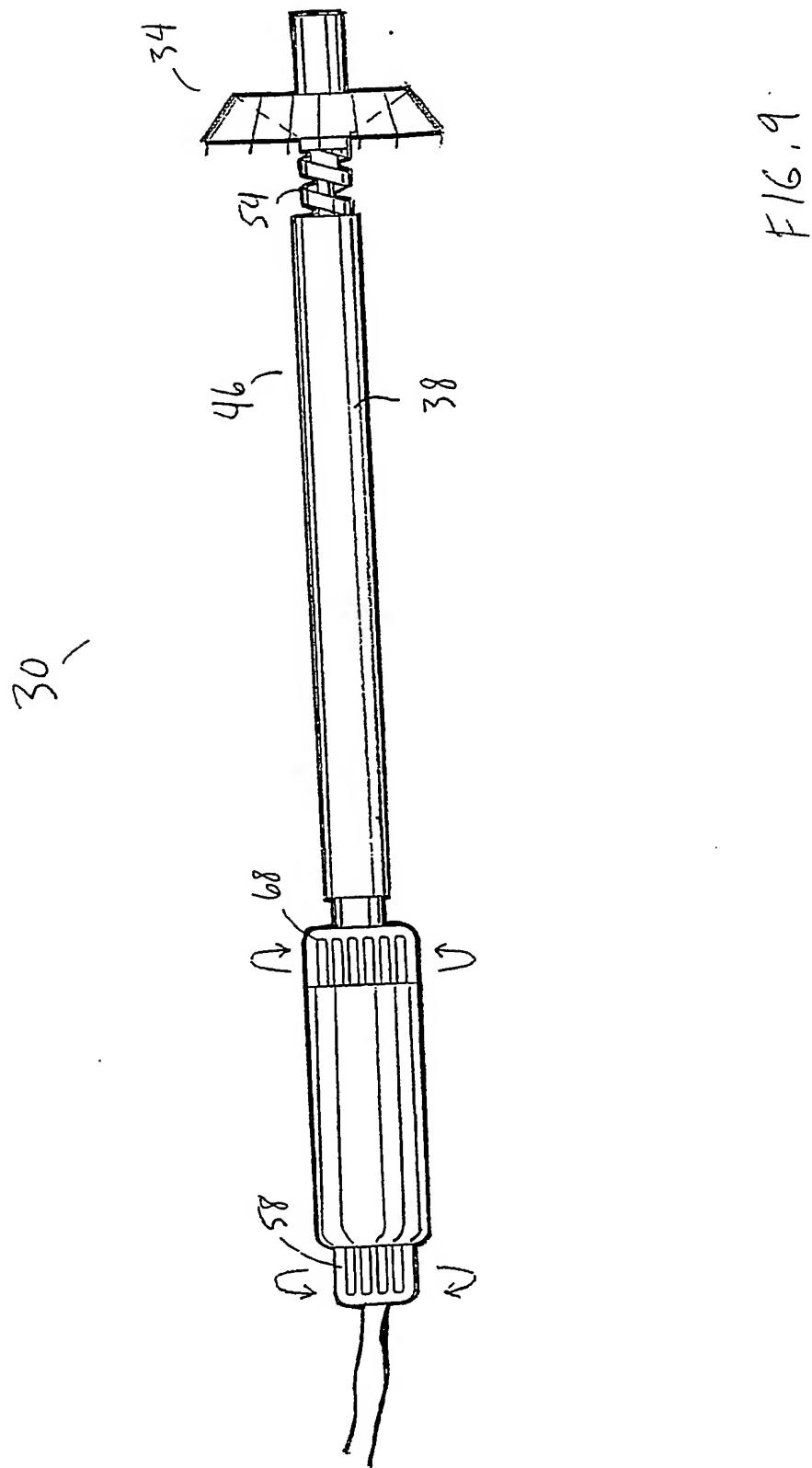


FIG. 10A

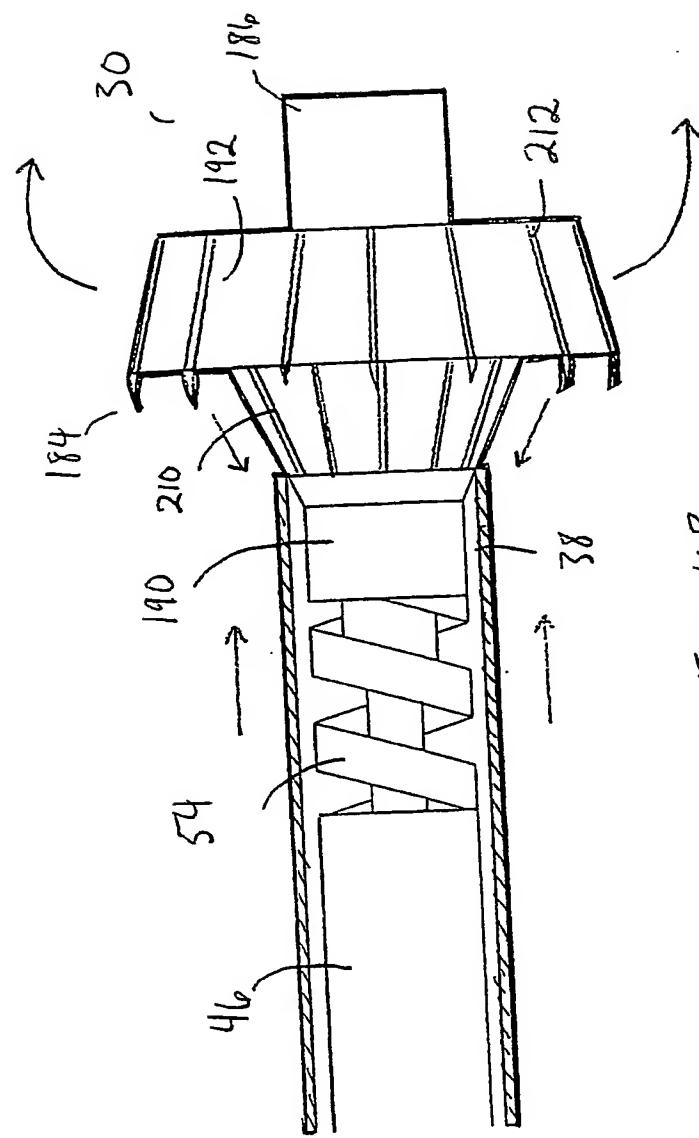
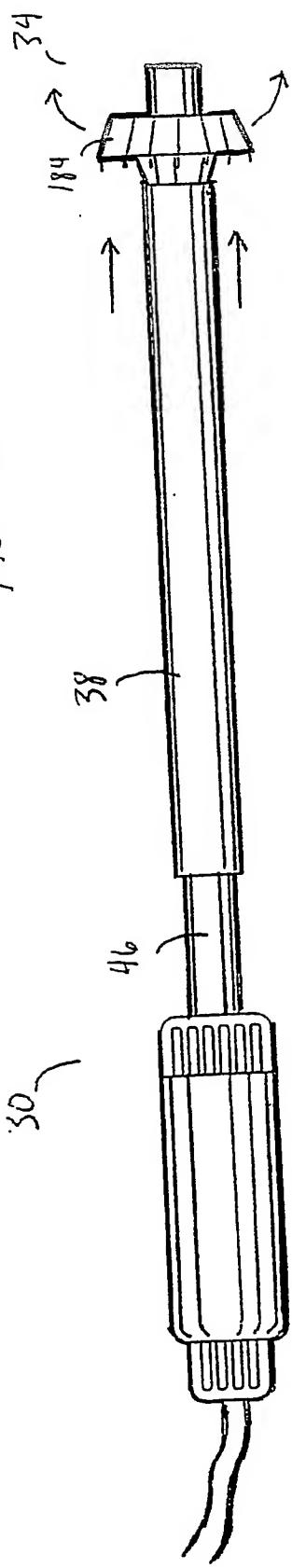
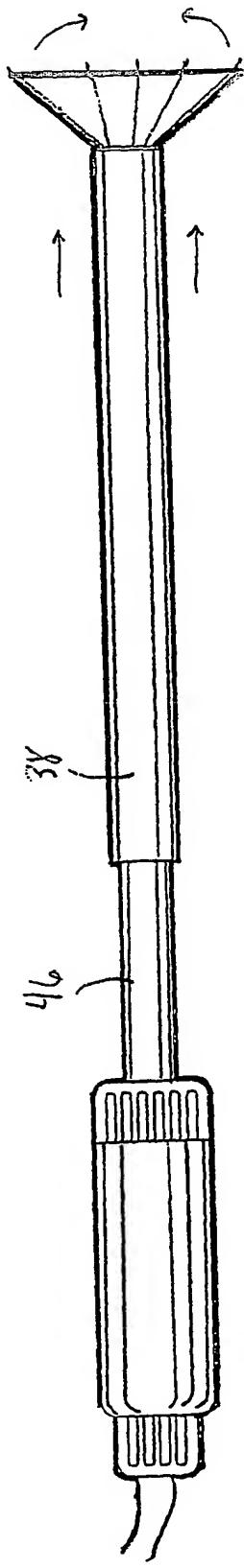


FIG. 10B

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FIG. 11A



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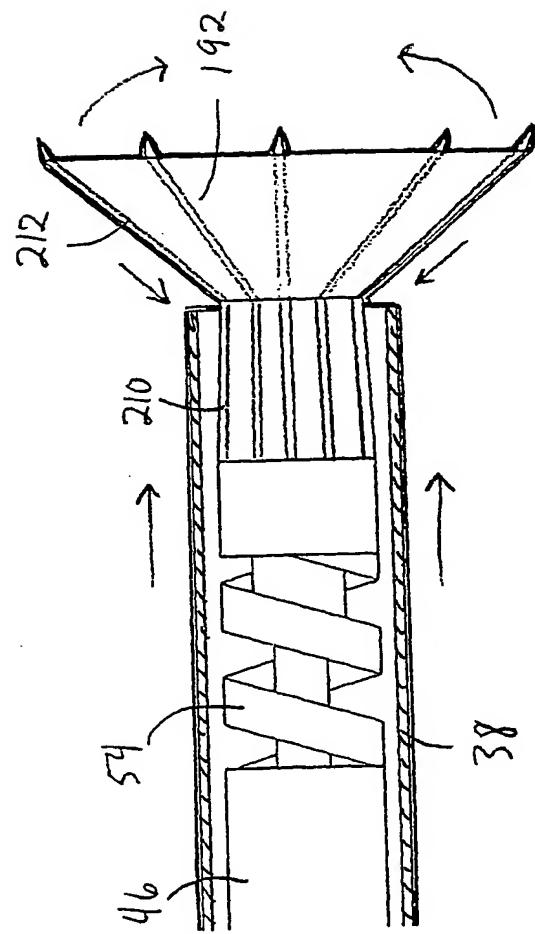


FIG. 11B

FIG. 12A

30,

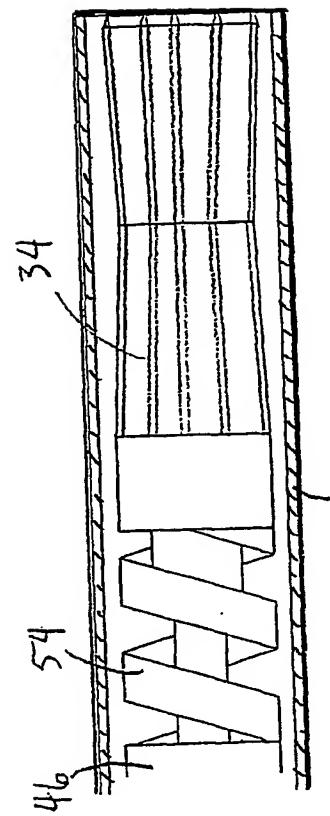
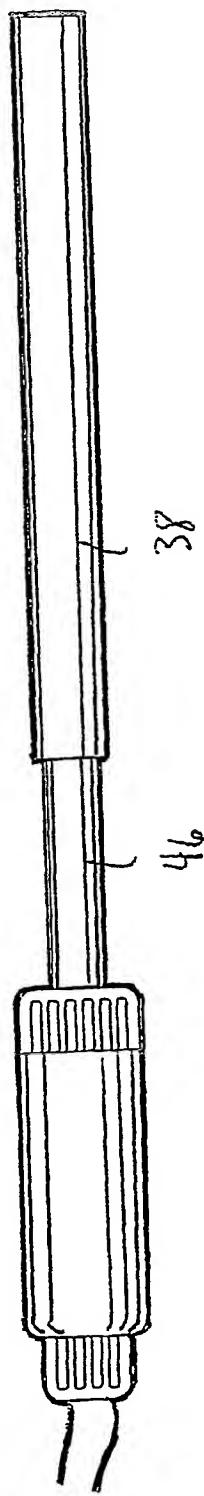


FIG. 12B

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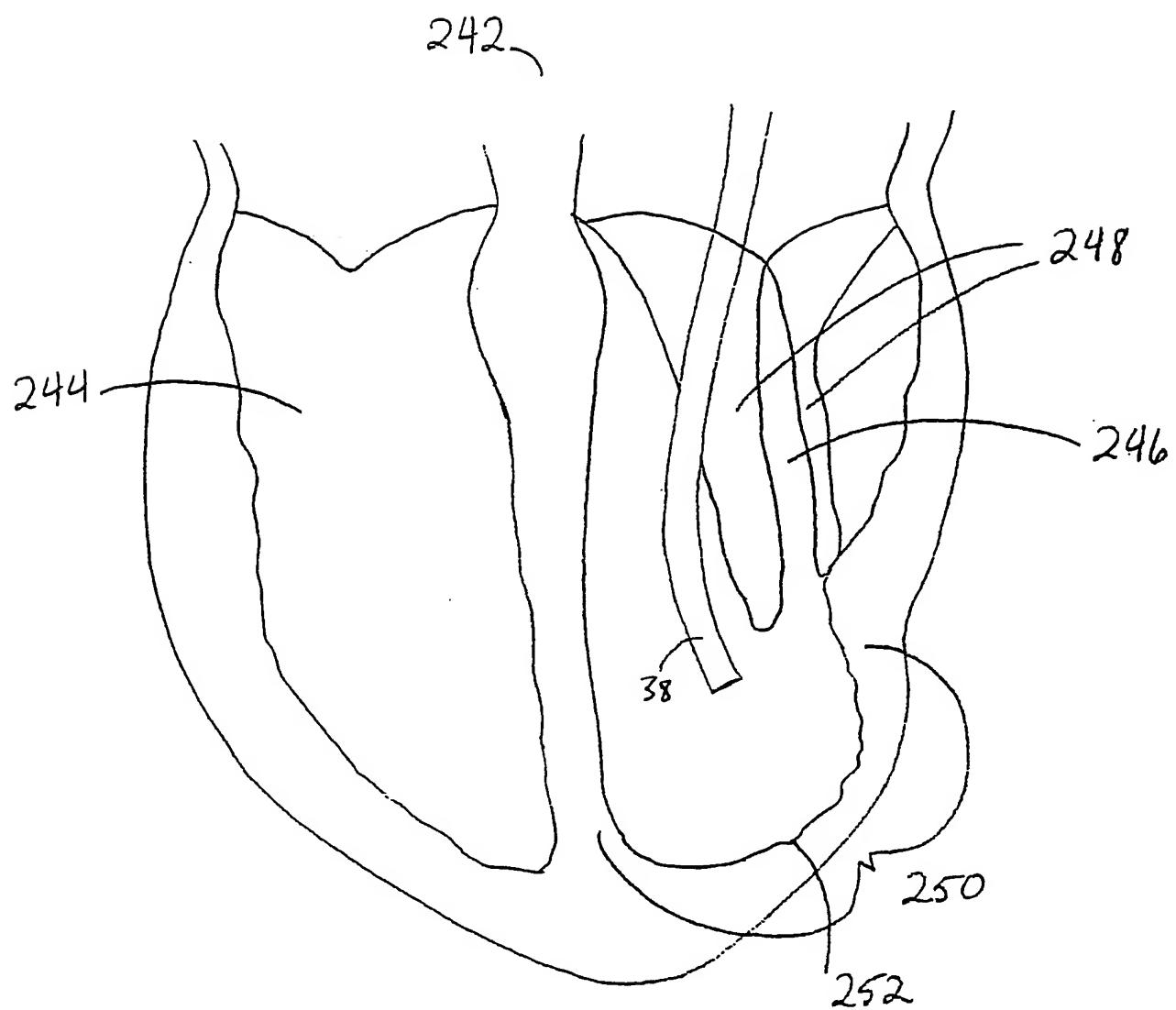


FIG. 13A

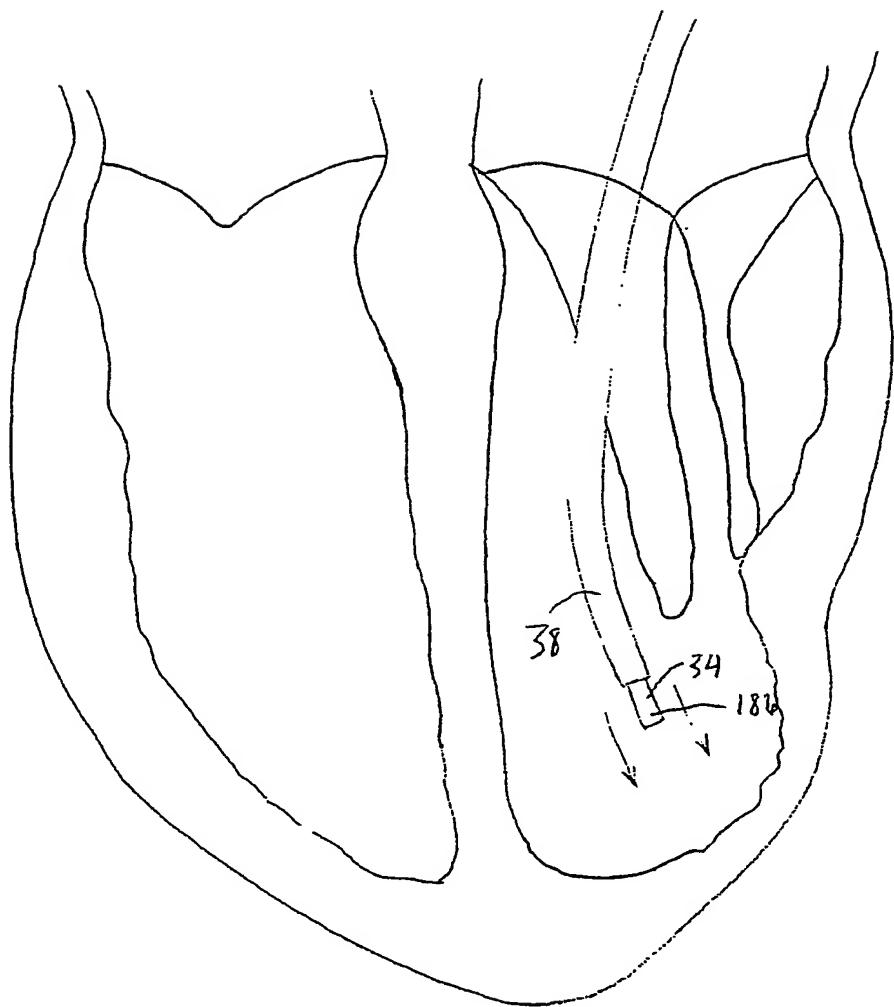


FIG. 13B

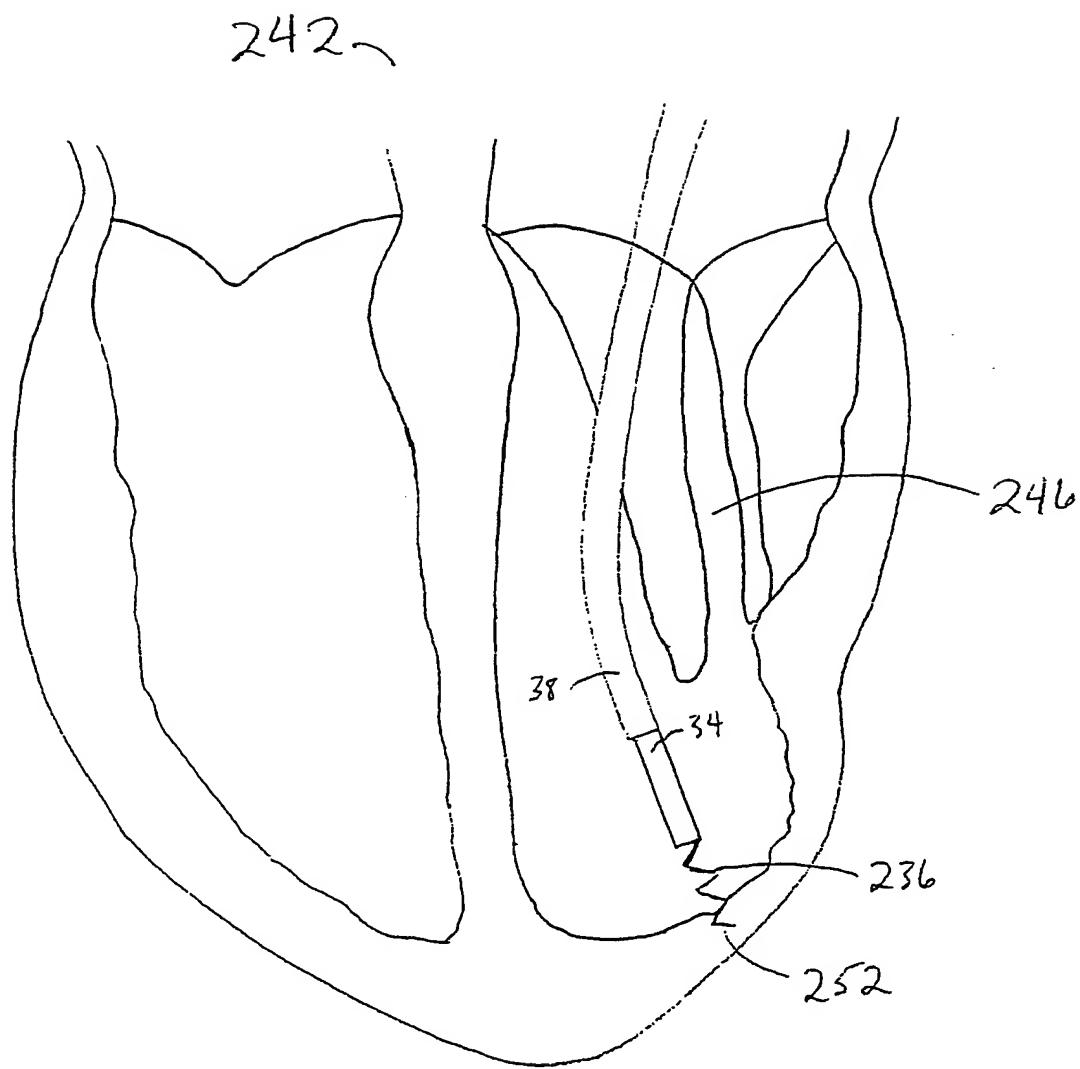


FIG. 13C

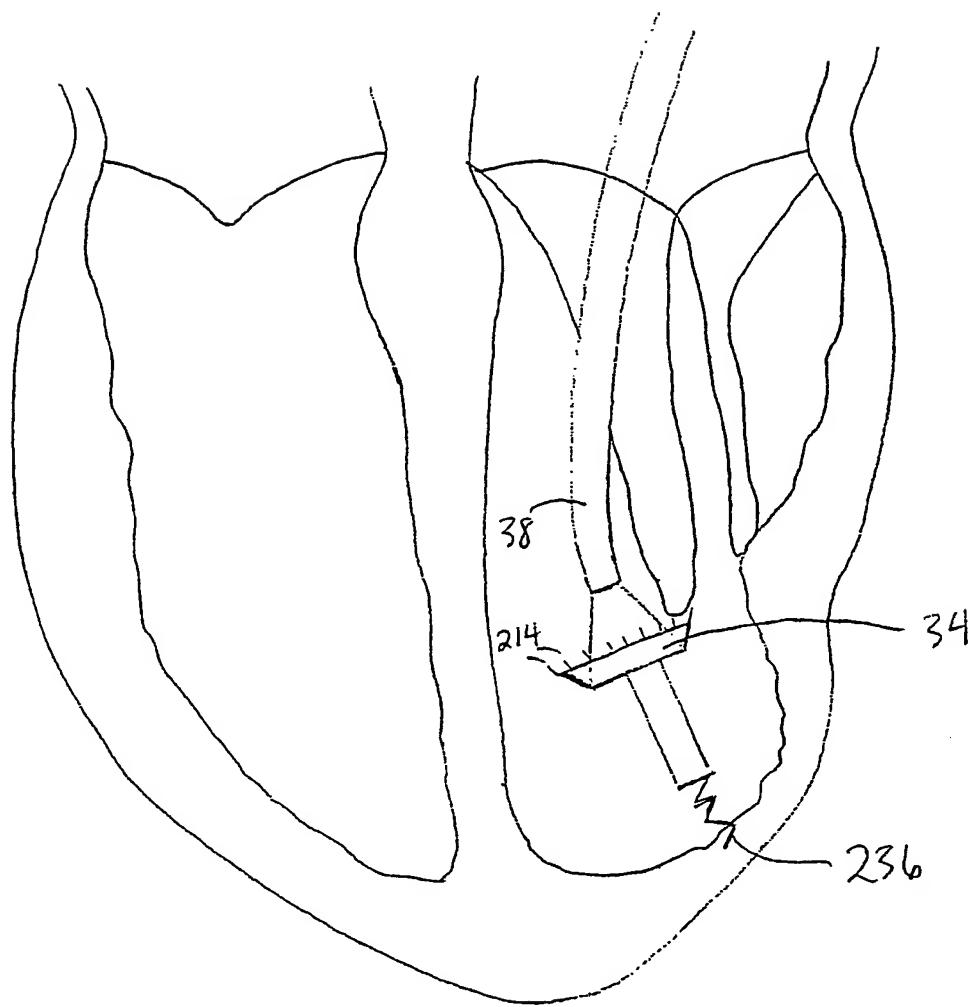


FIG. 13D

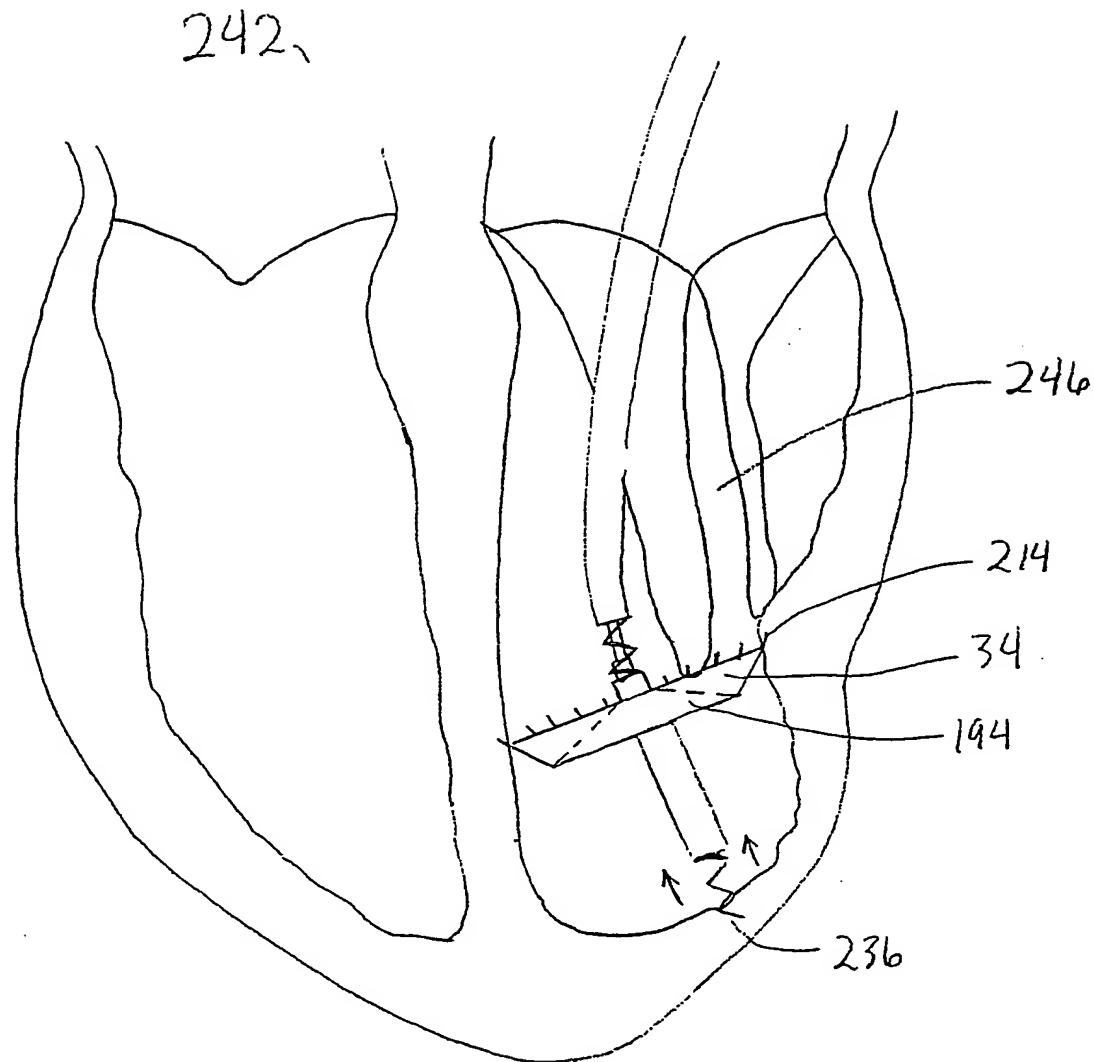
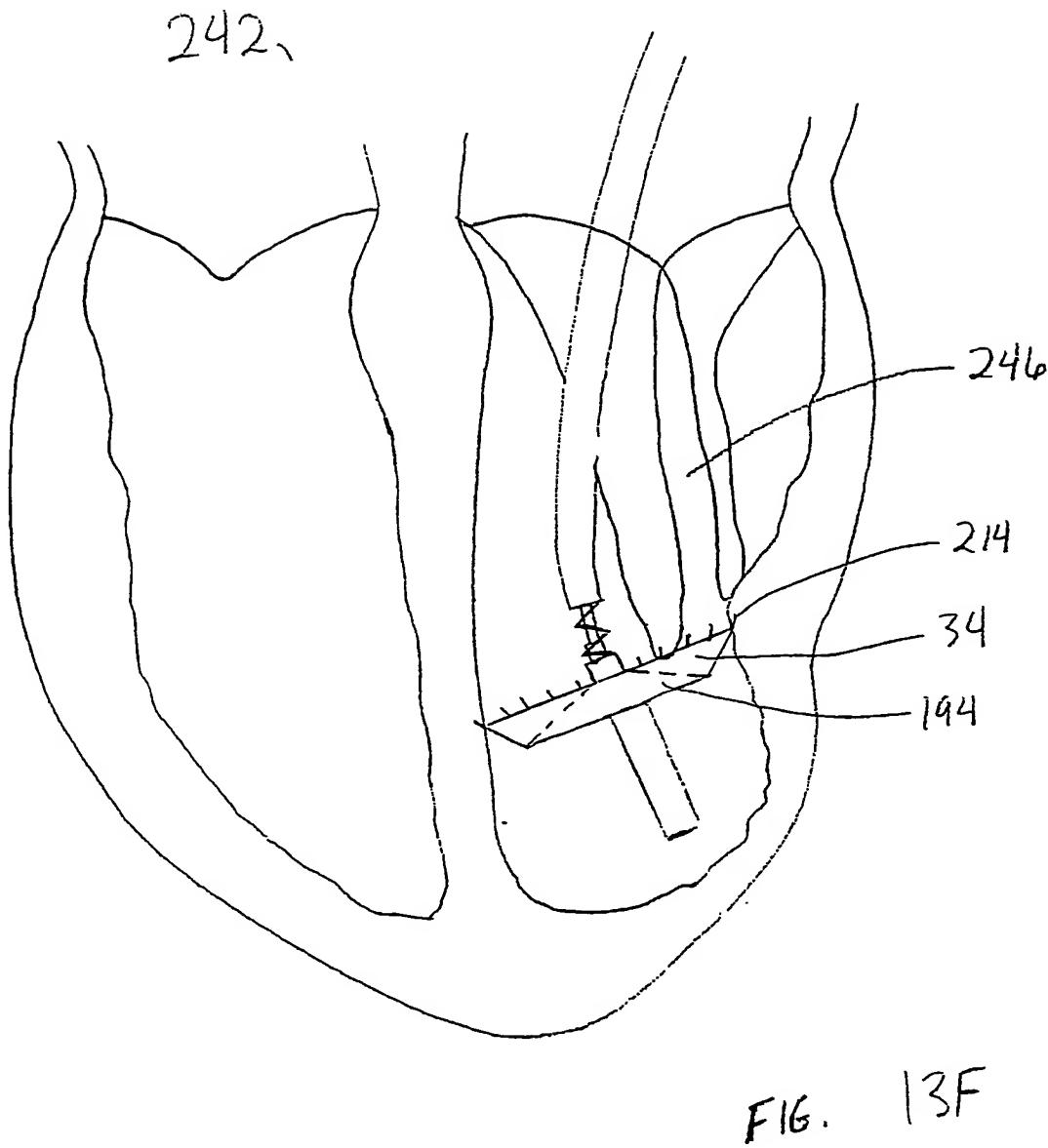


FIG. 13E



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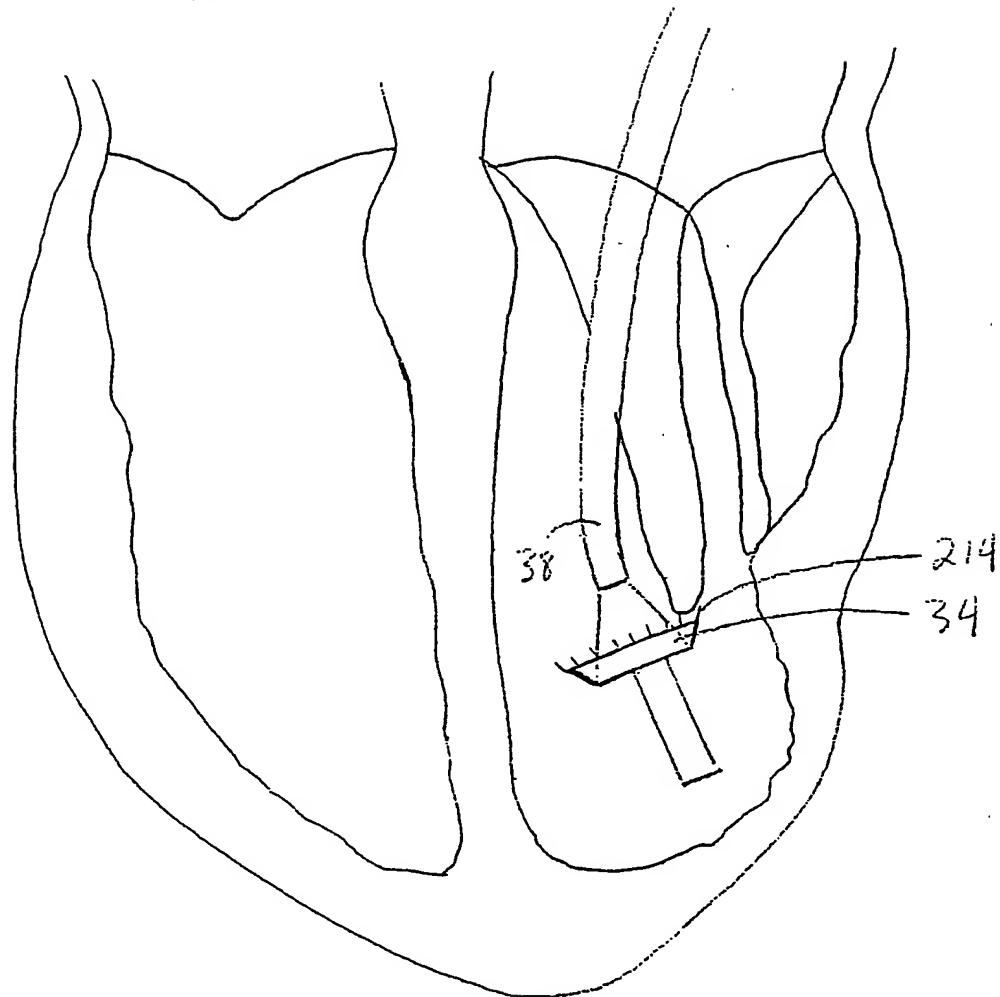


FIG. 13G

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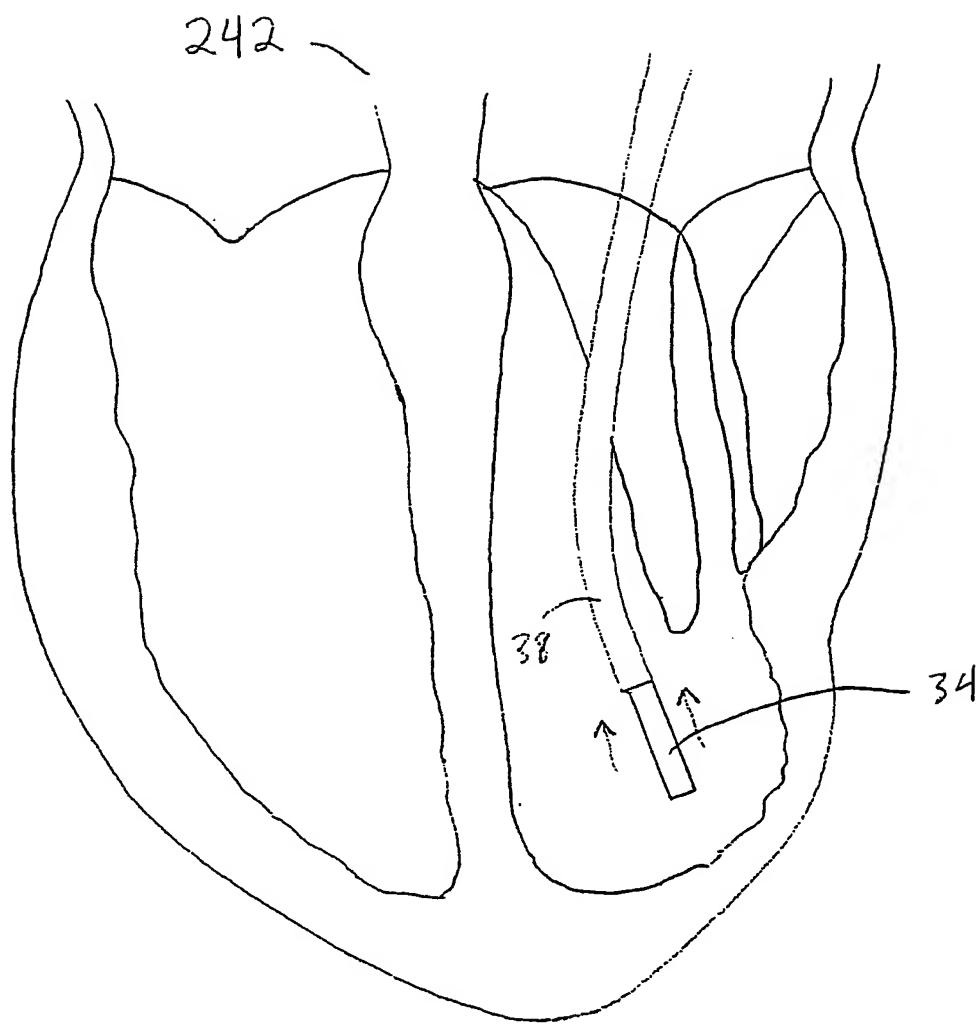


FIG. 13H

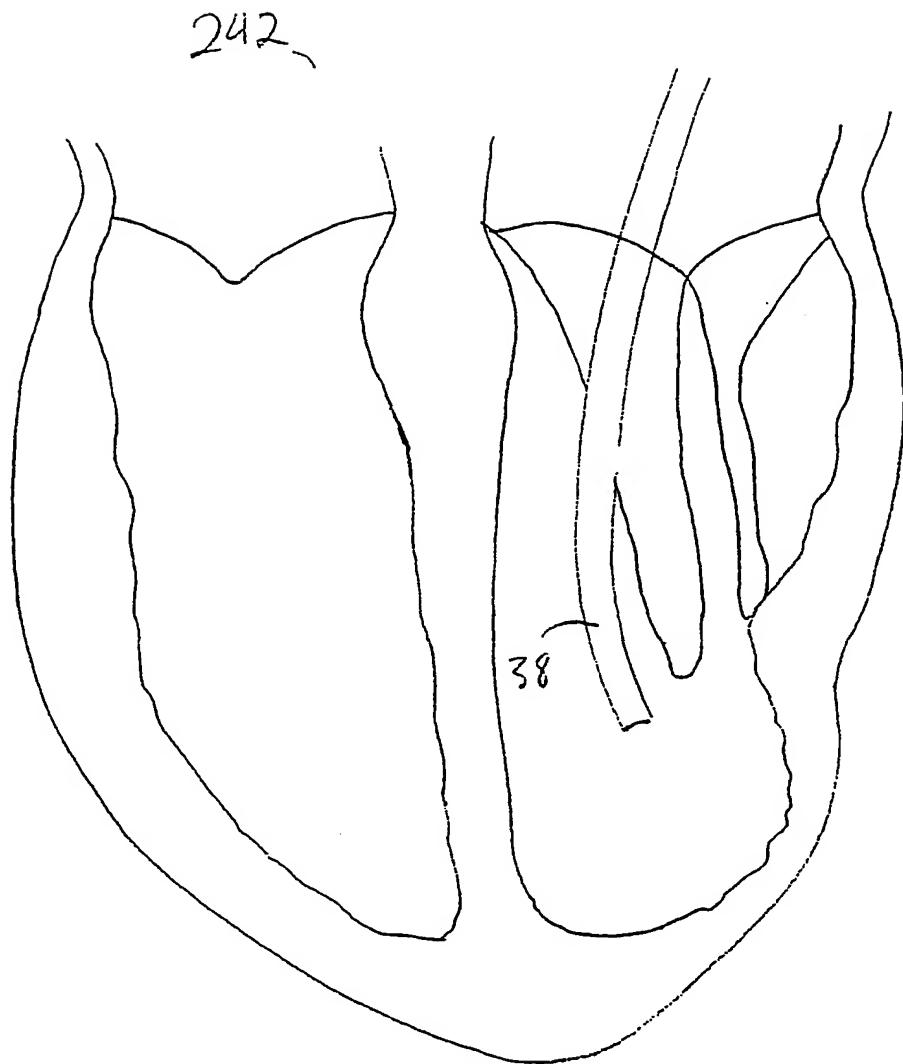


FIG. 13I

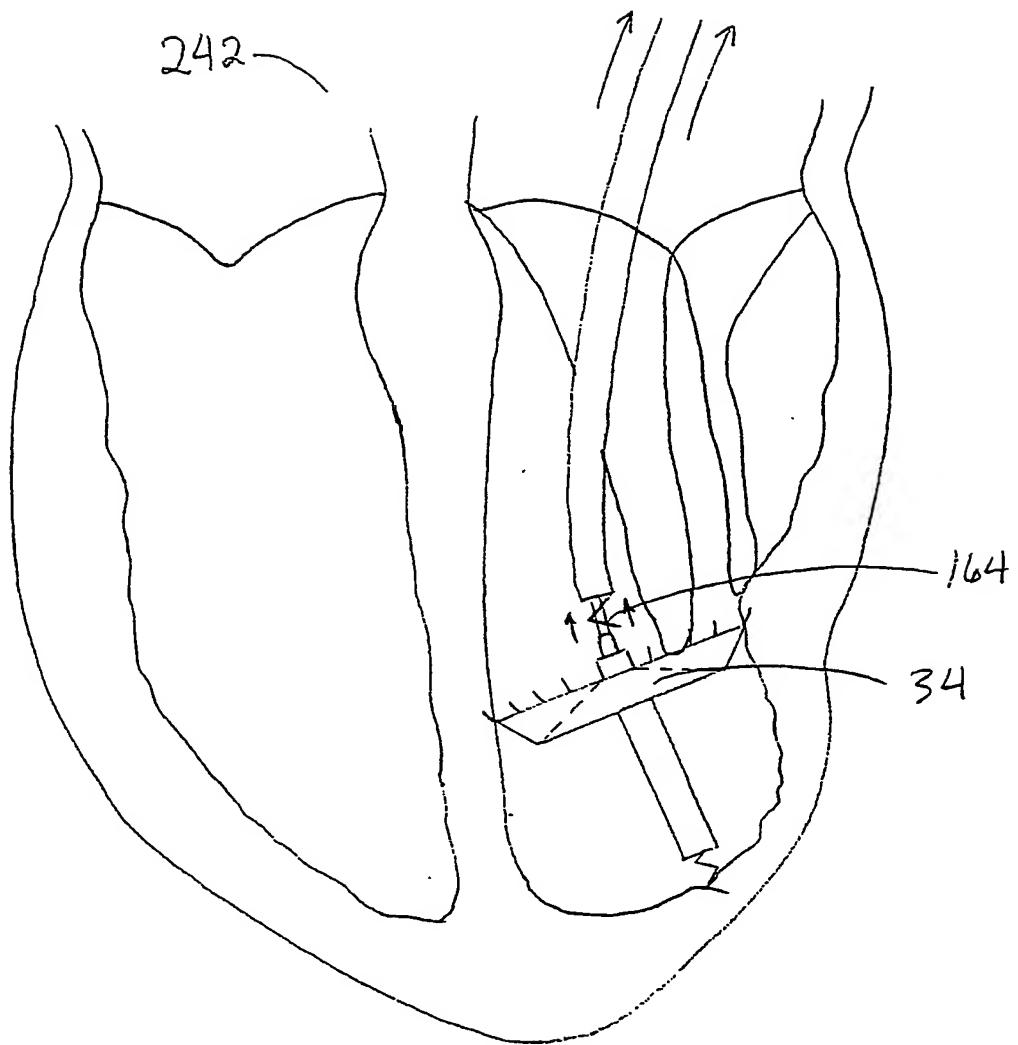


FIG. 13J

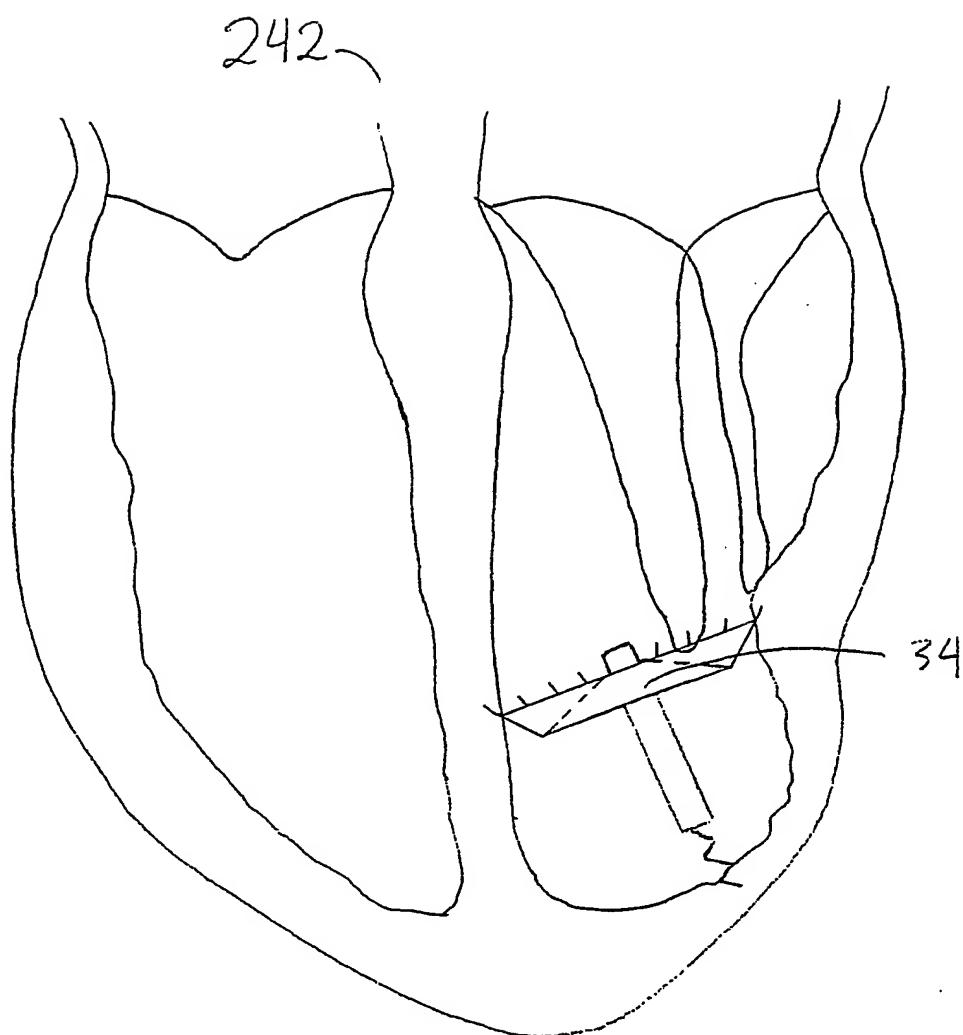


FIG. 13K

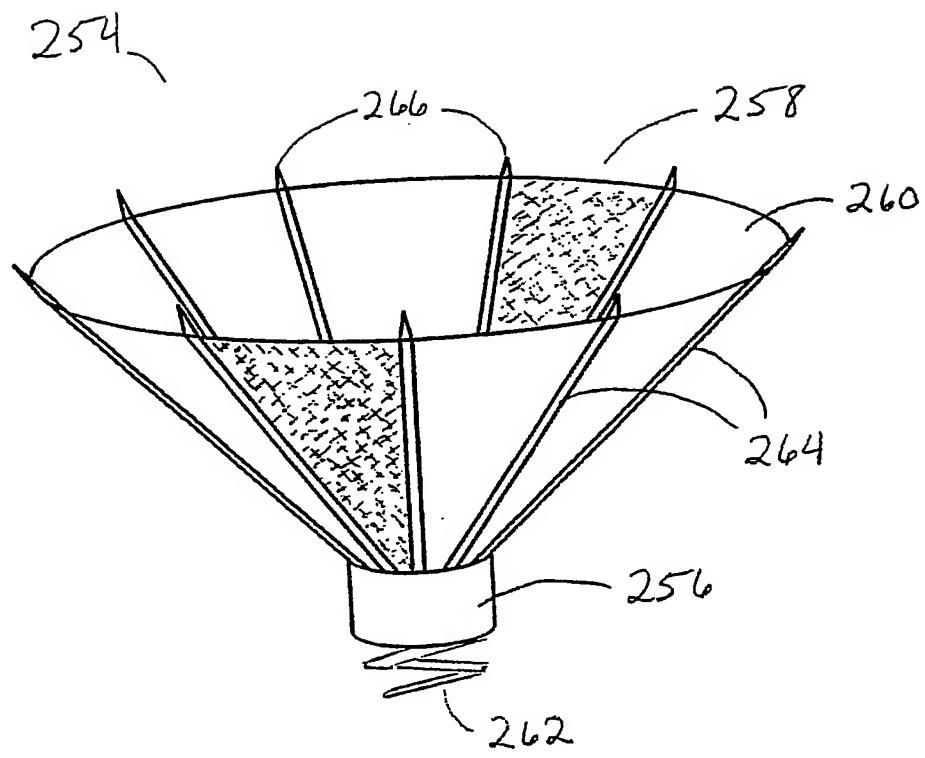


FIG. 14A

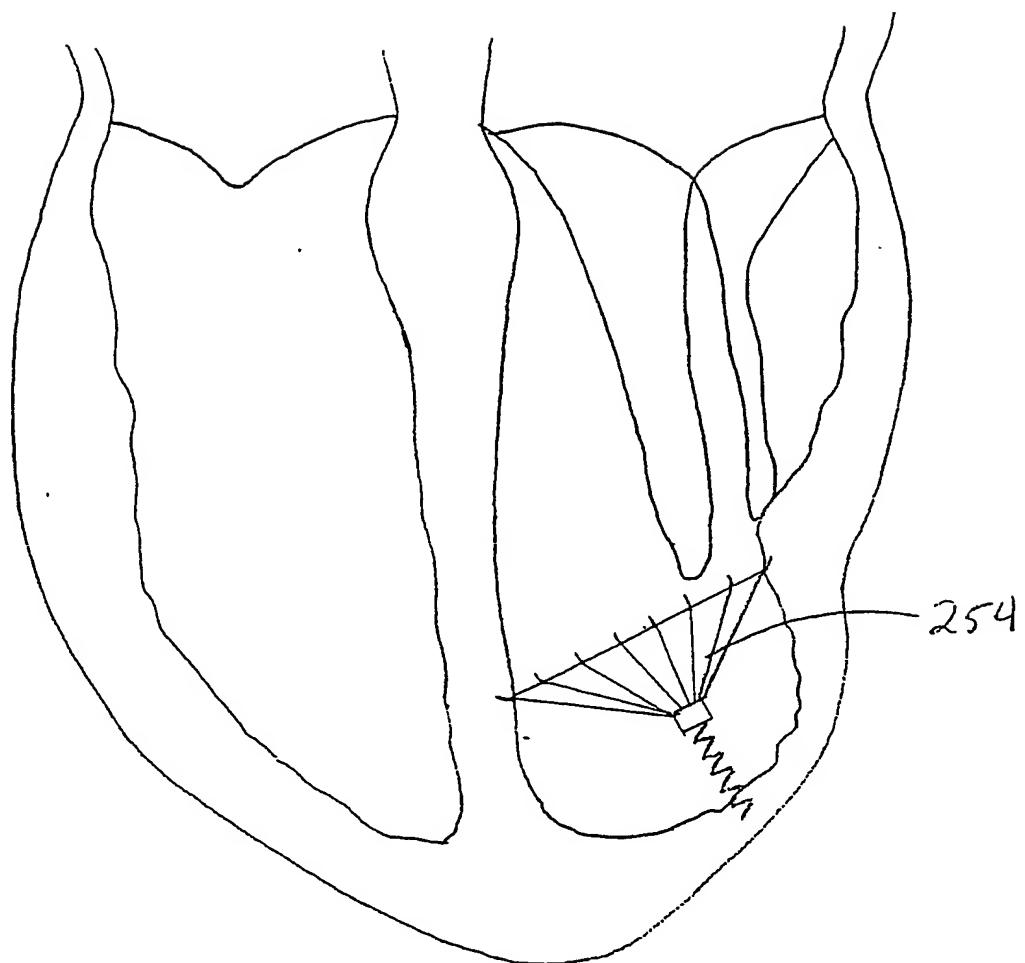


FIG. 14B

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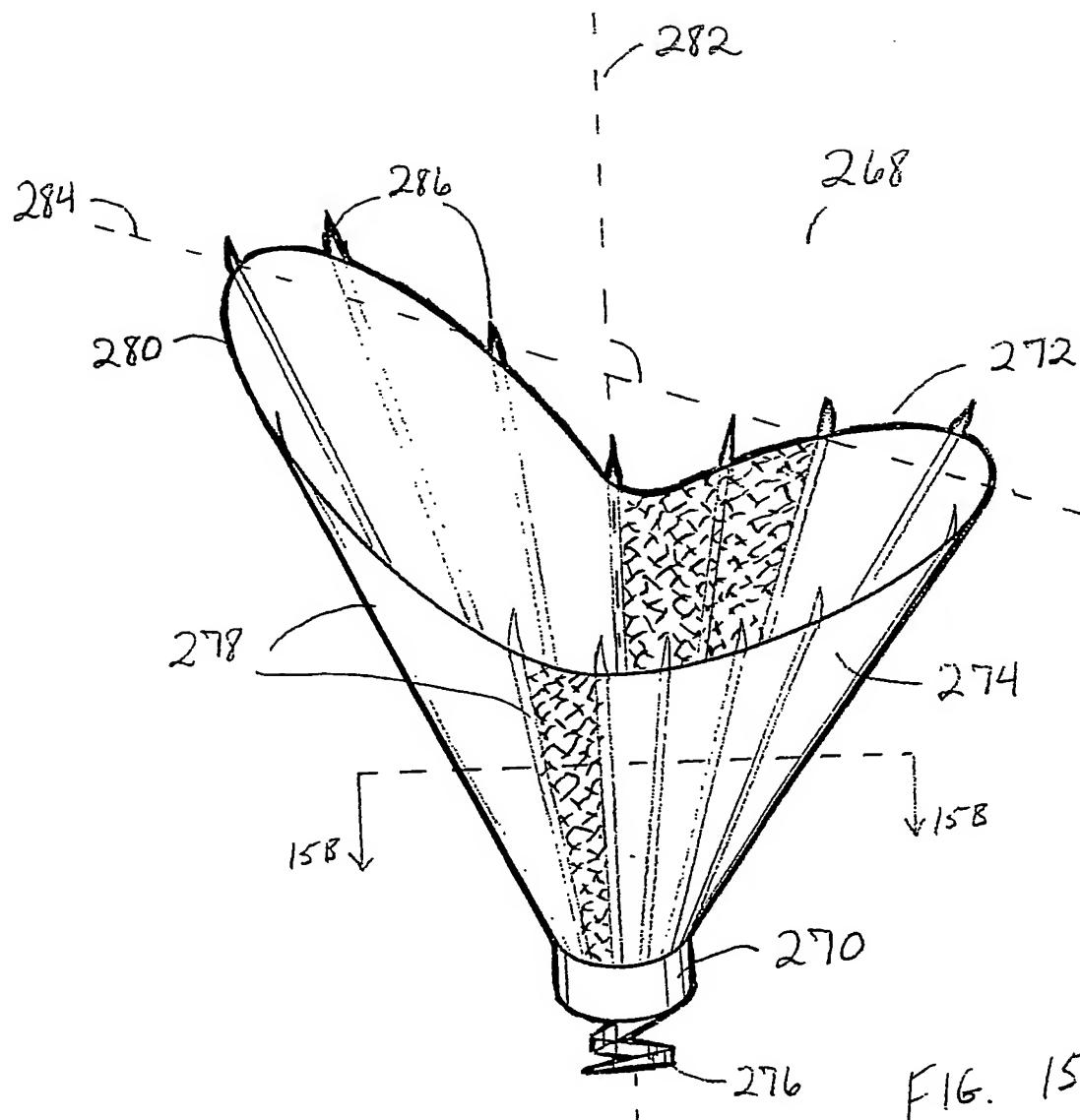
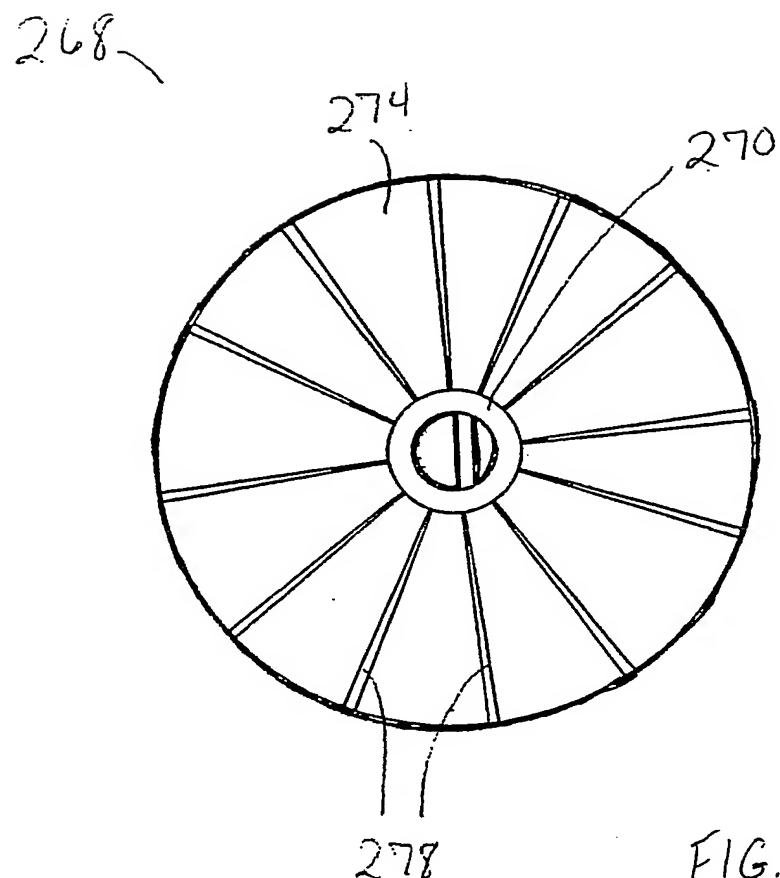


FIG. 15A



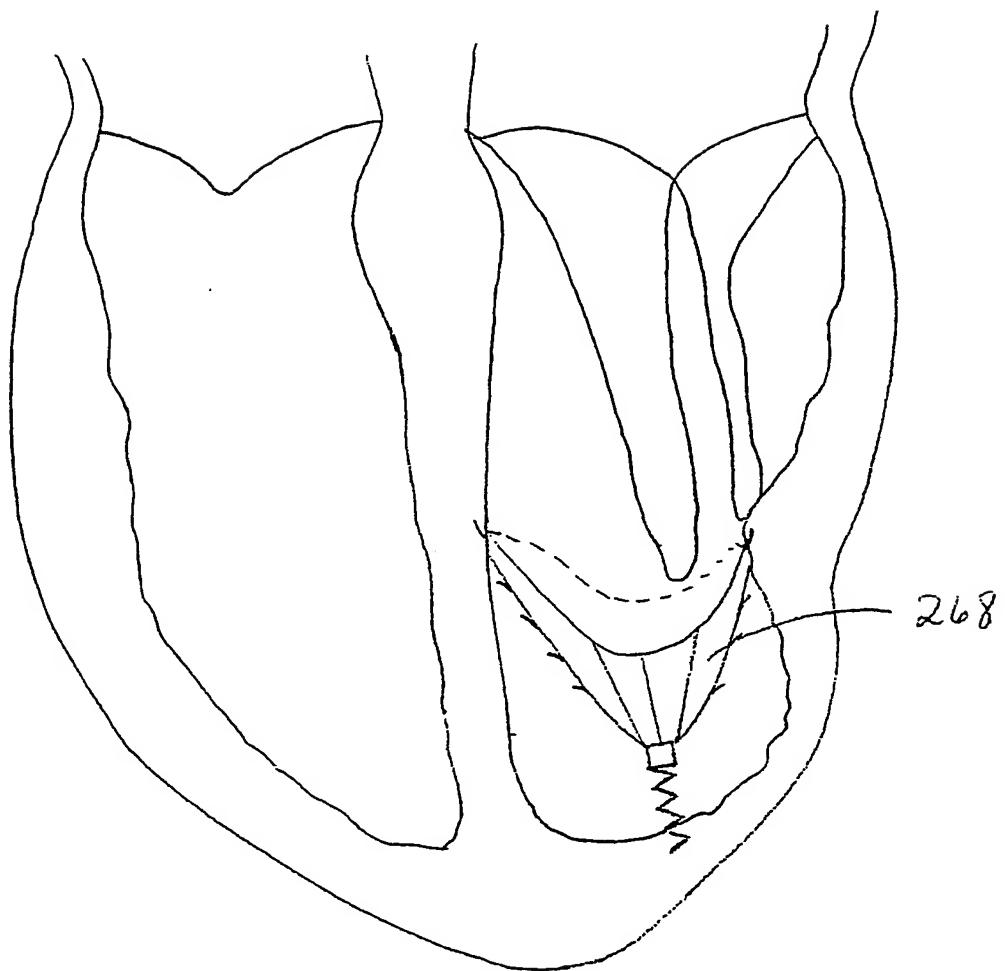


FIG. 15C

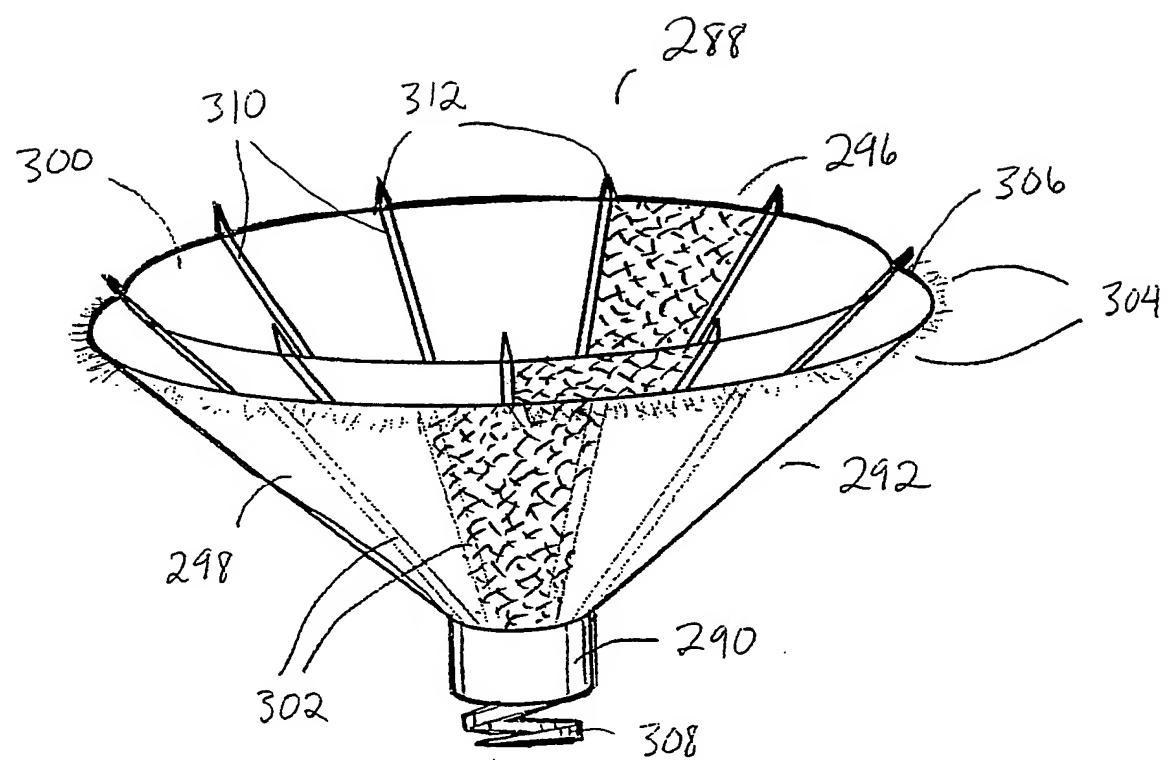


FIG. 16A

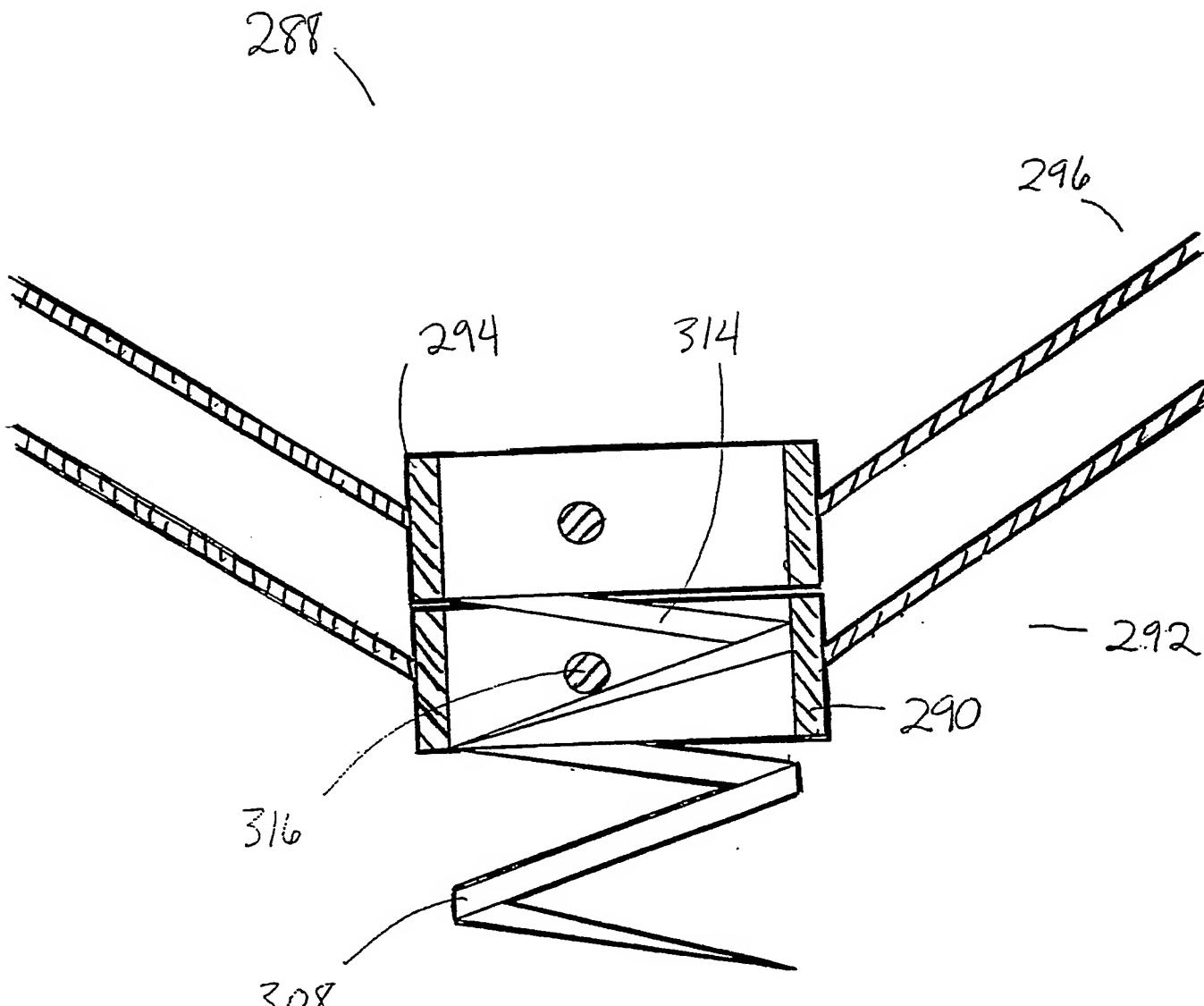


FIG. 16B

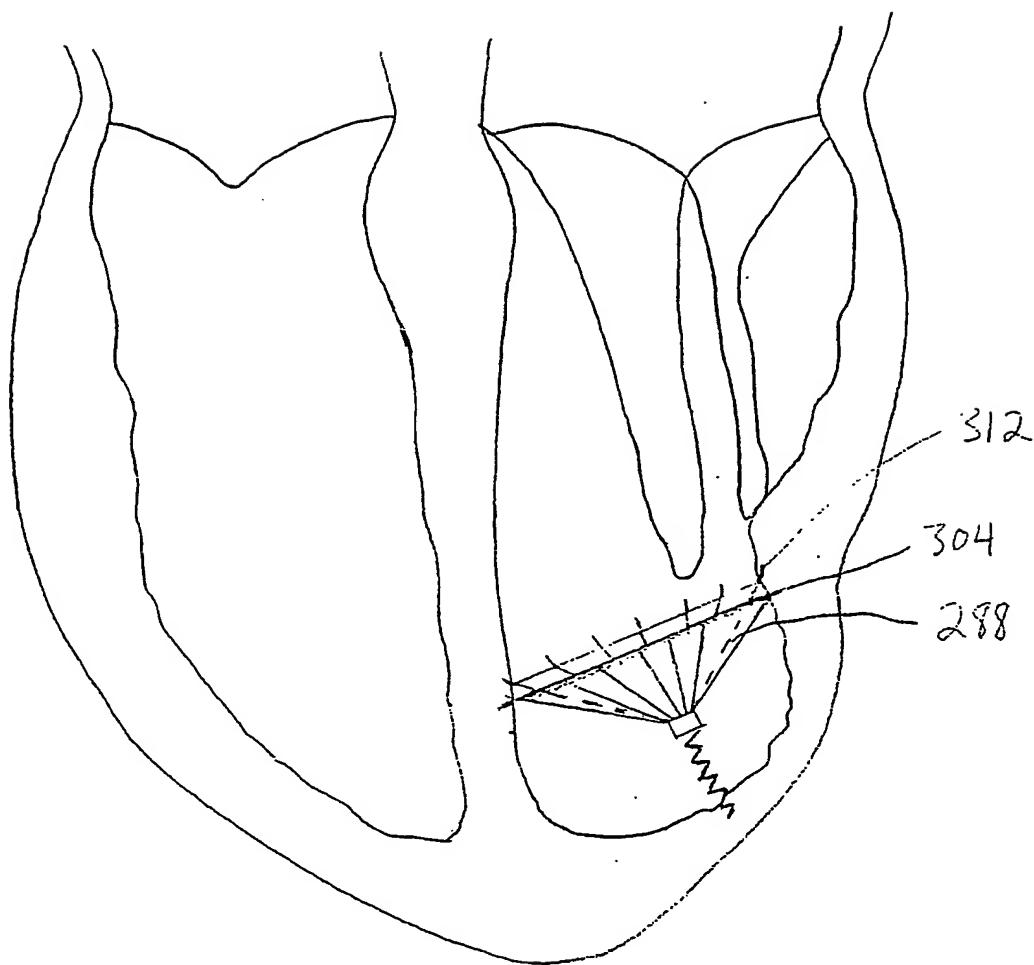


FIG. 16C

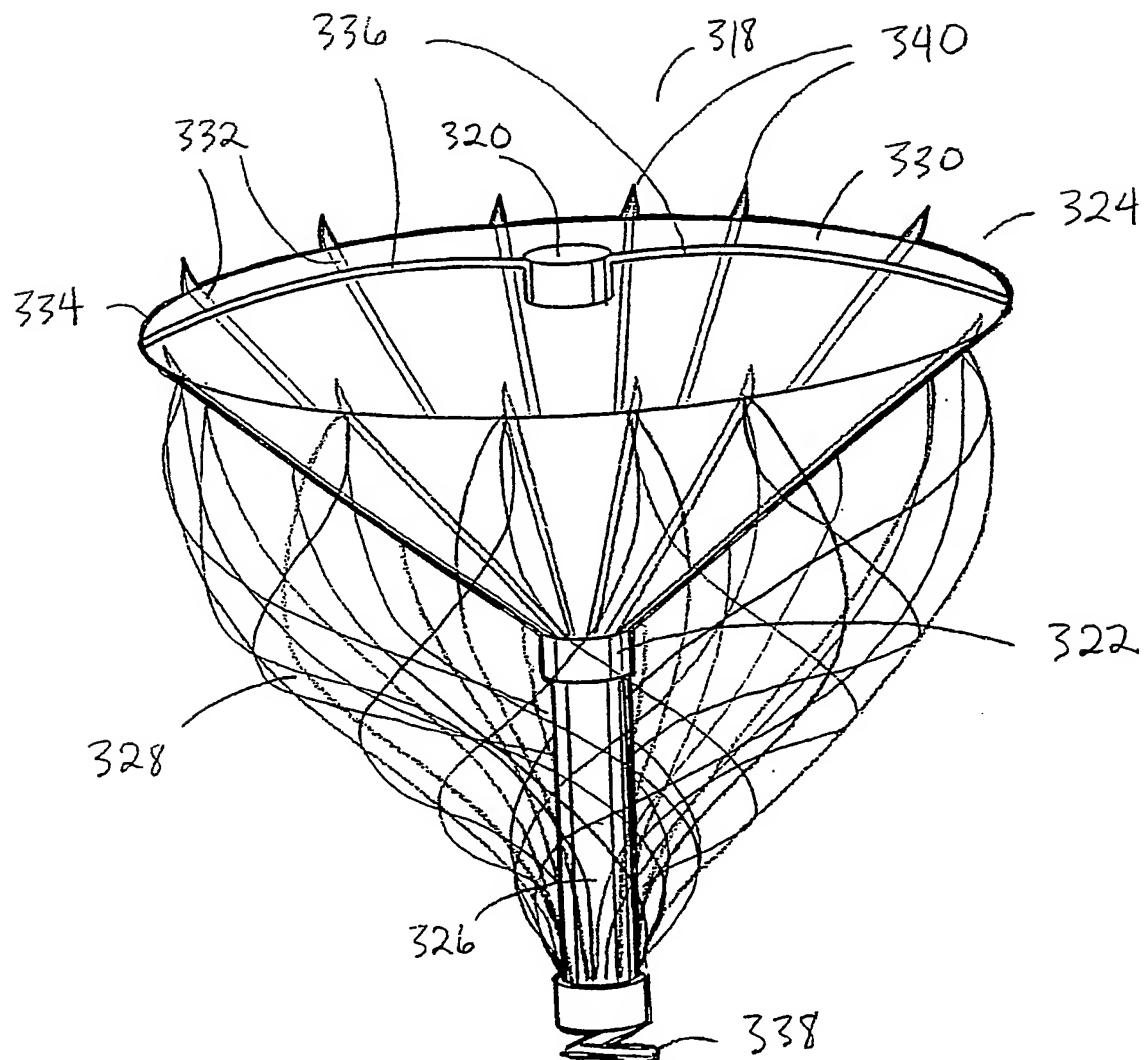


FIG. 17A

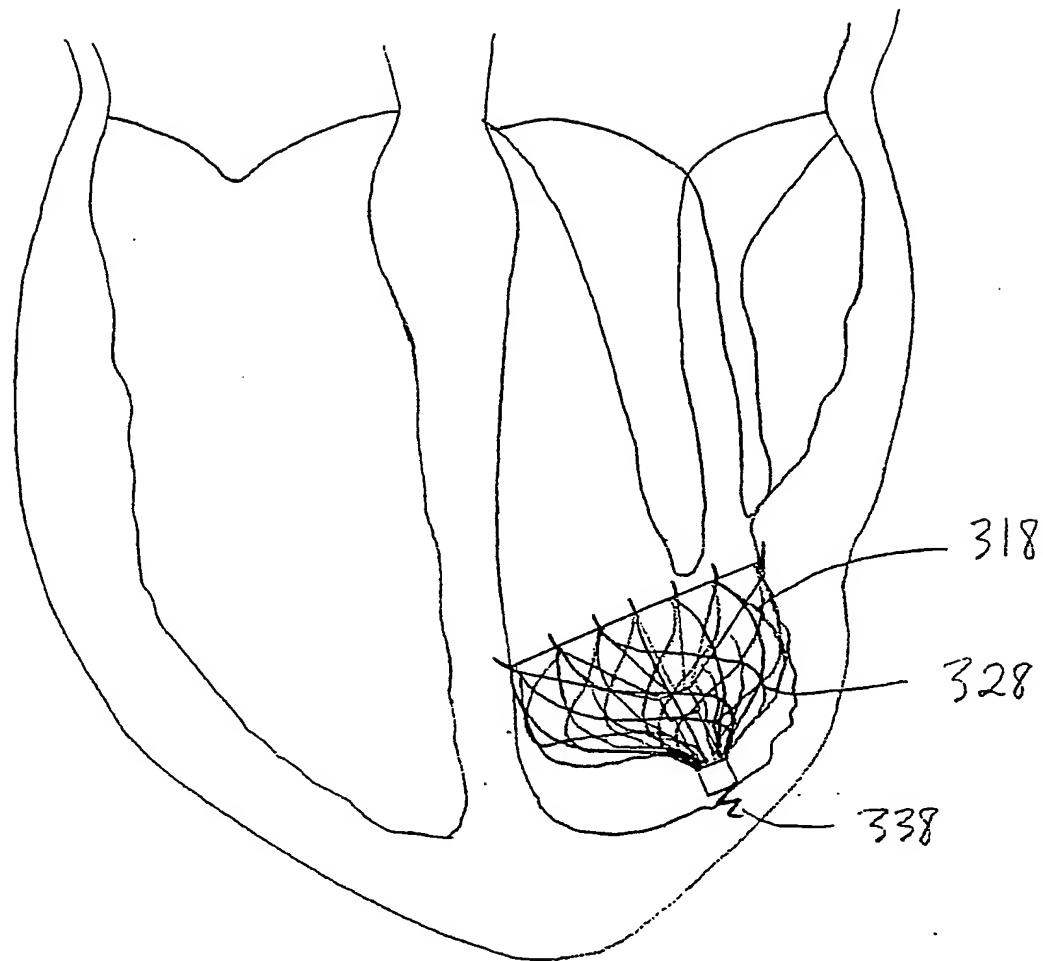
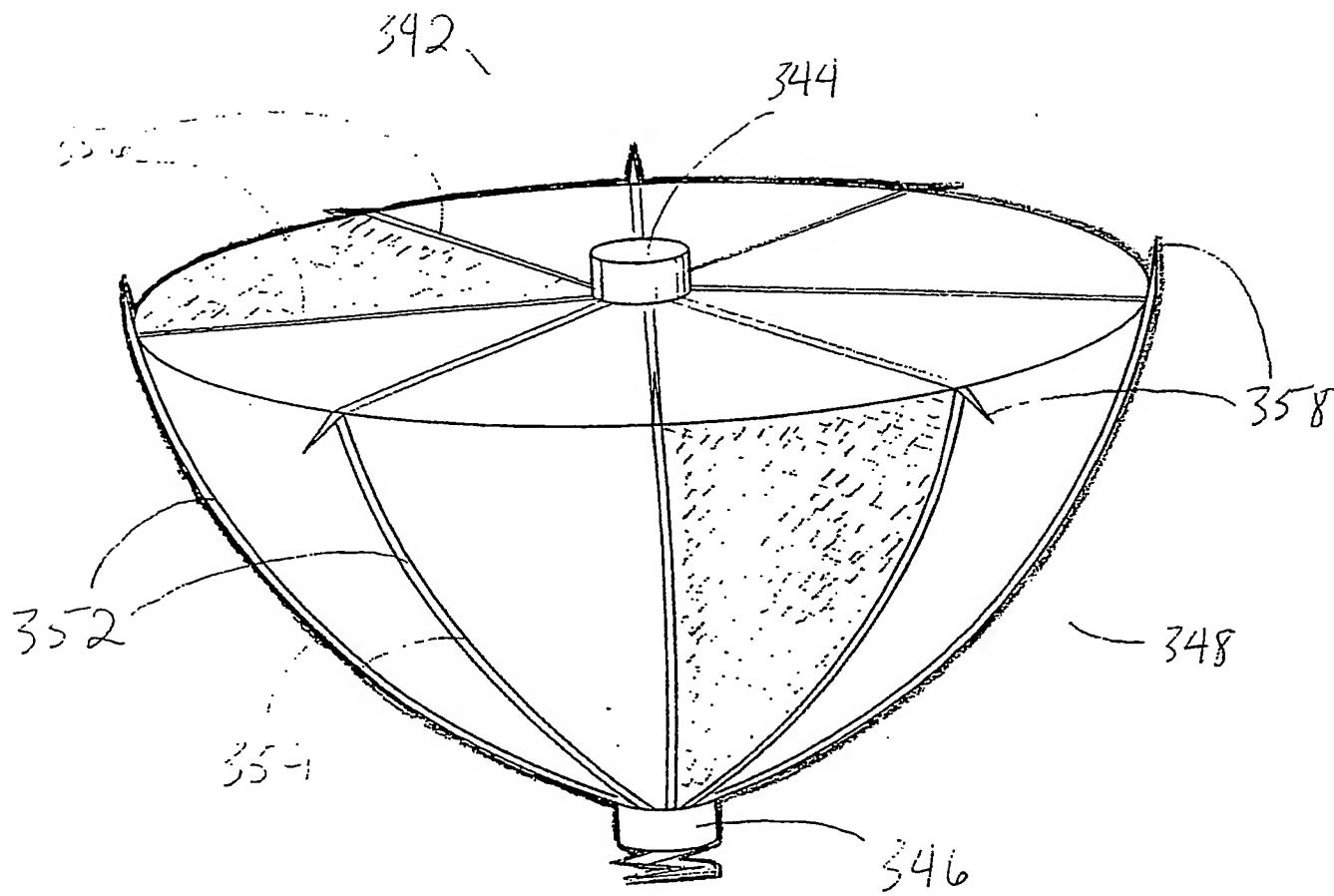


FIG. 17B



18A

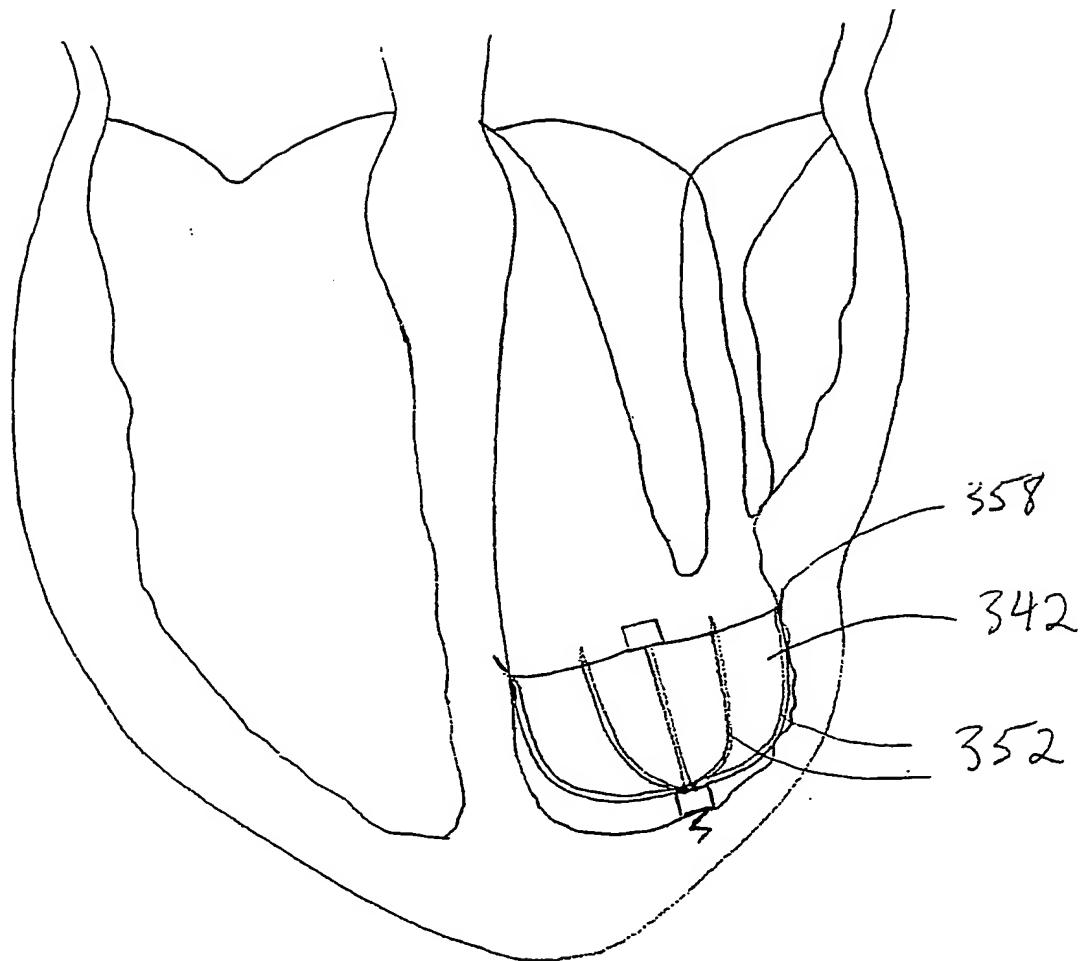


FIG. 18B

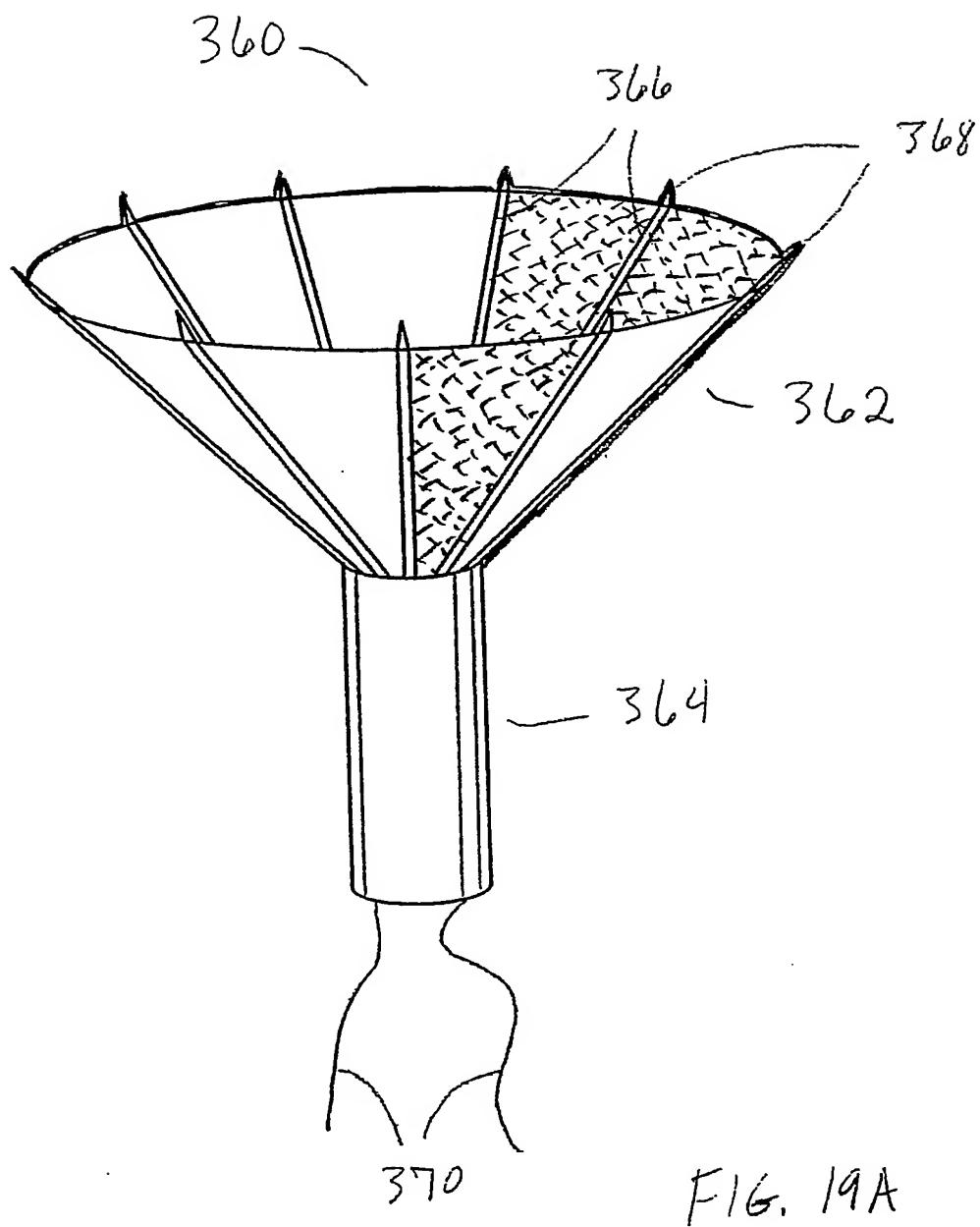


FIG. 19A

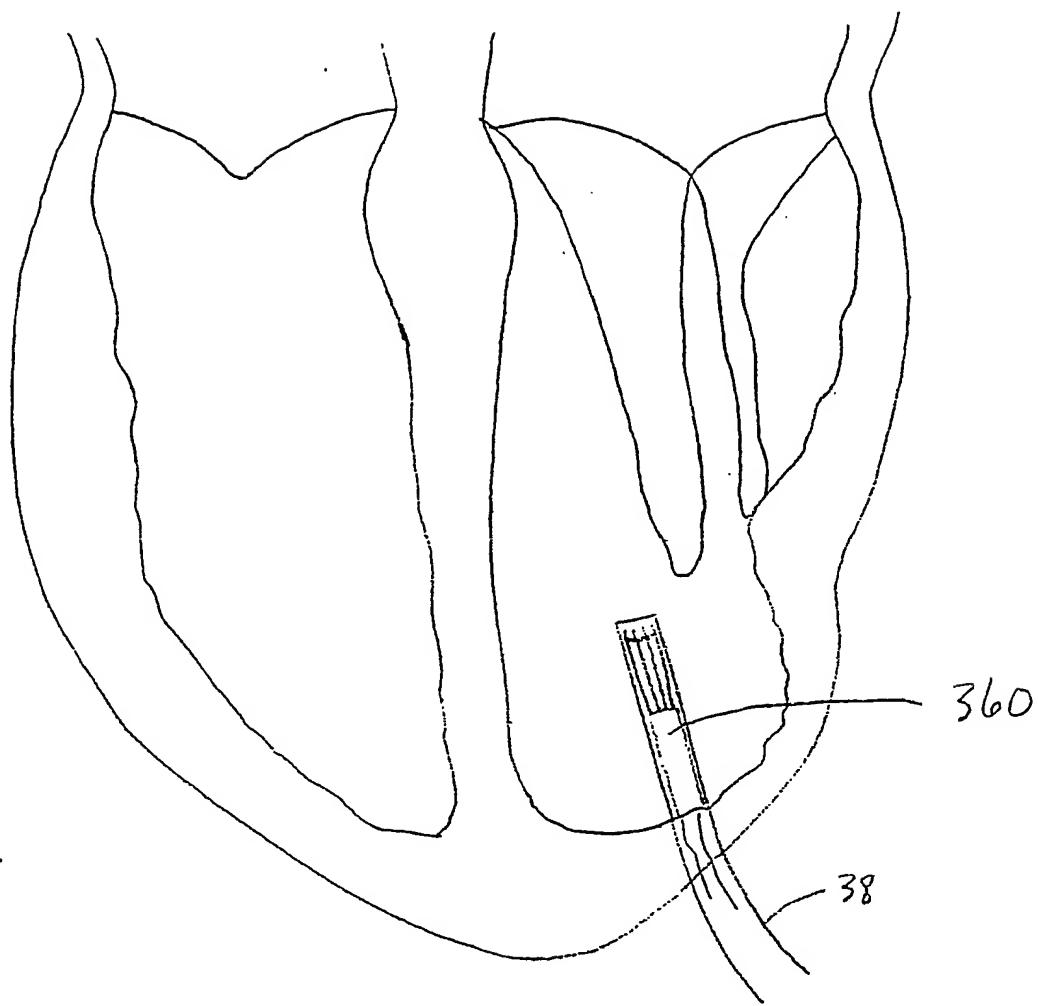
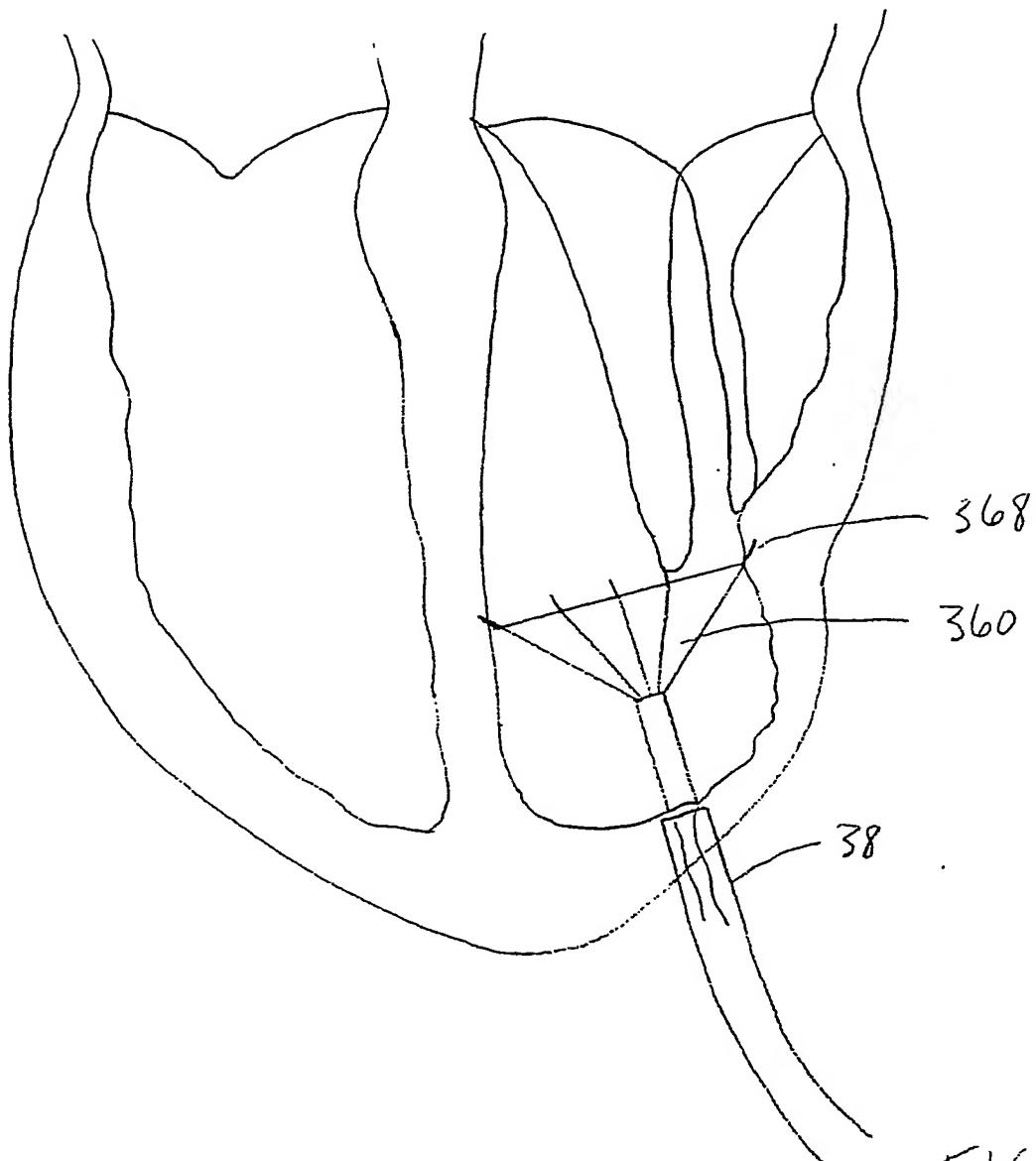
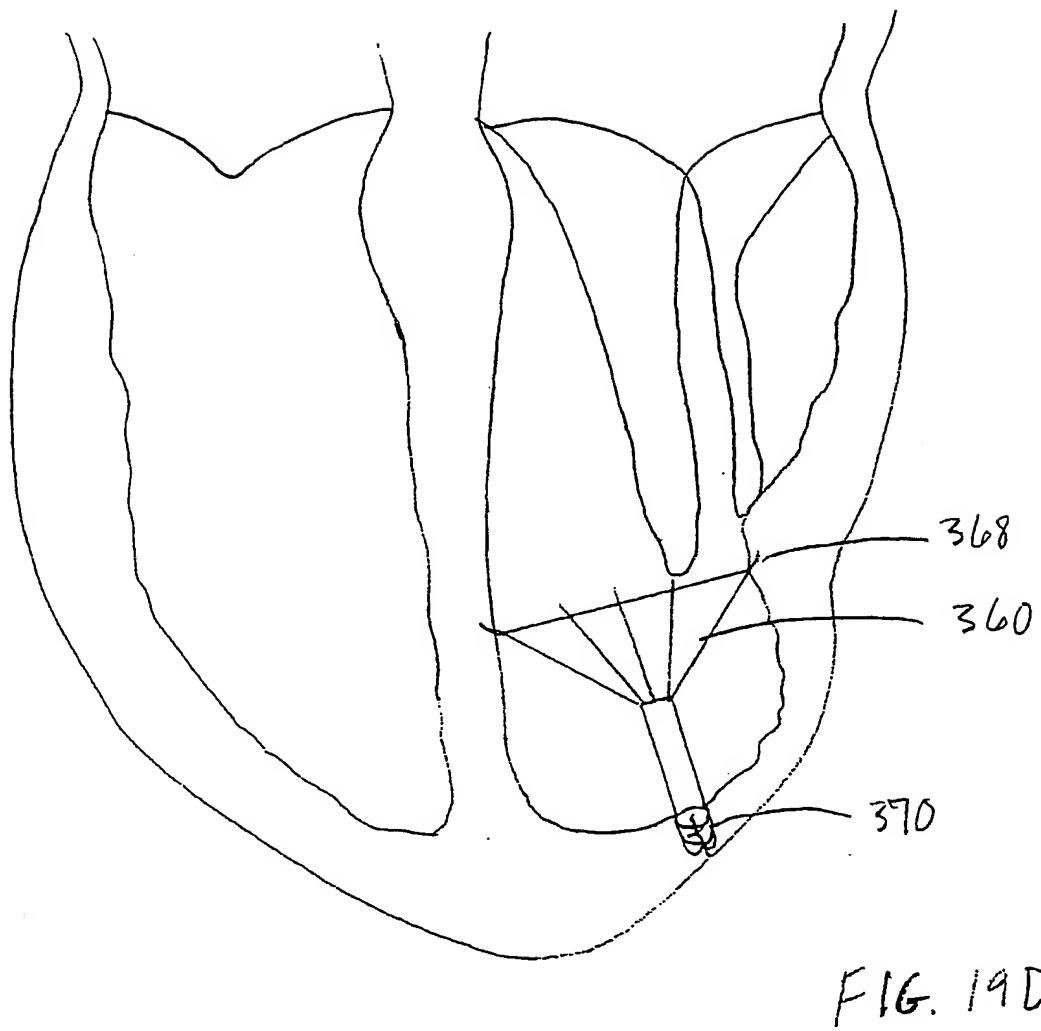


FIG. 19B





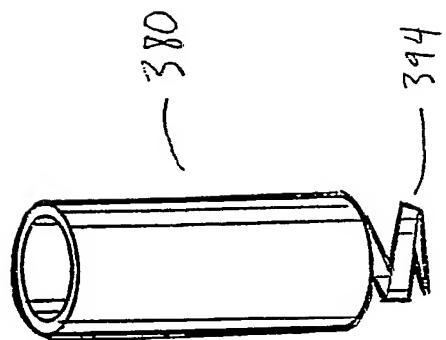


FIG. 20B

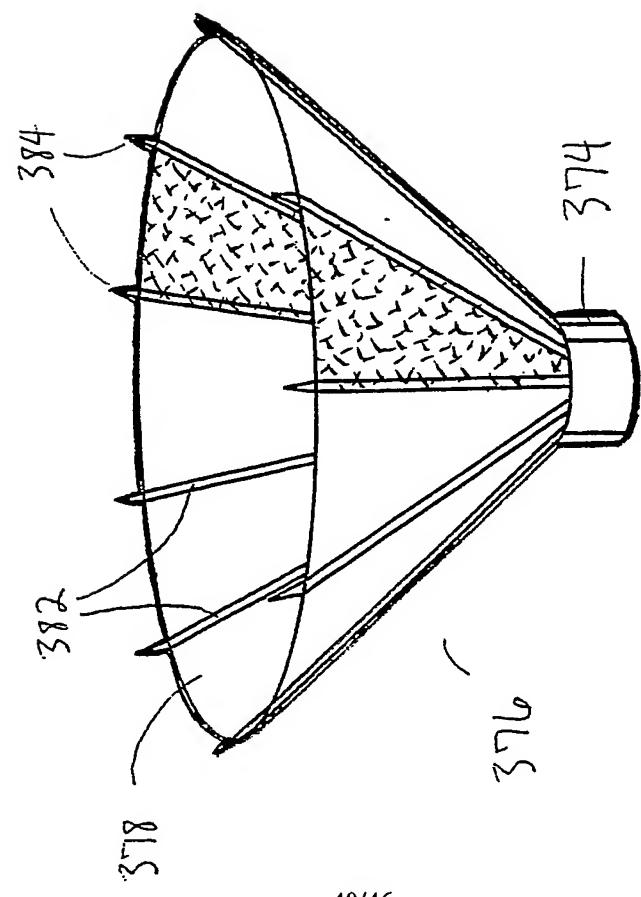


FIG. 20A

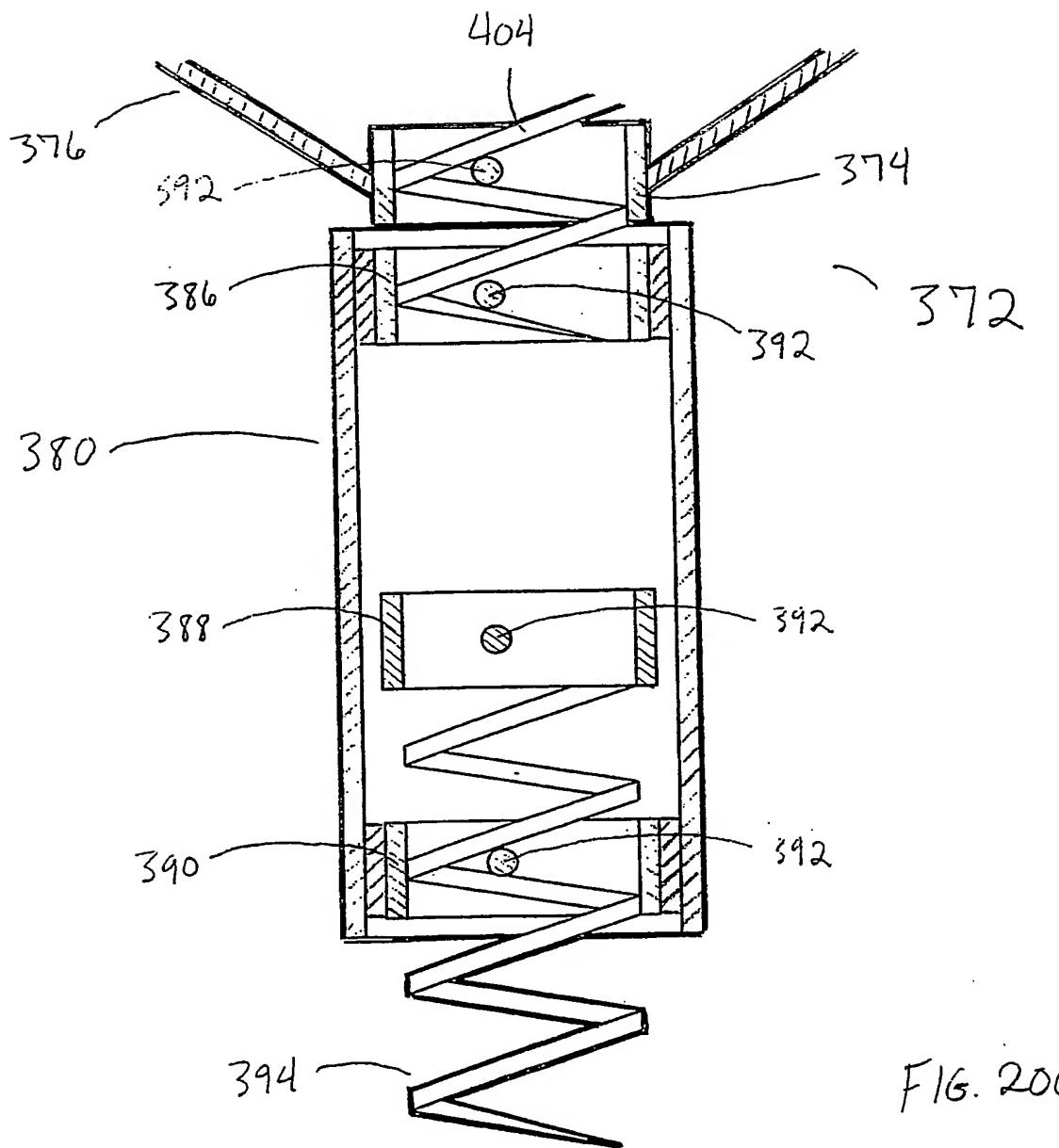


FIG. 20C

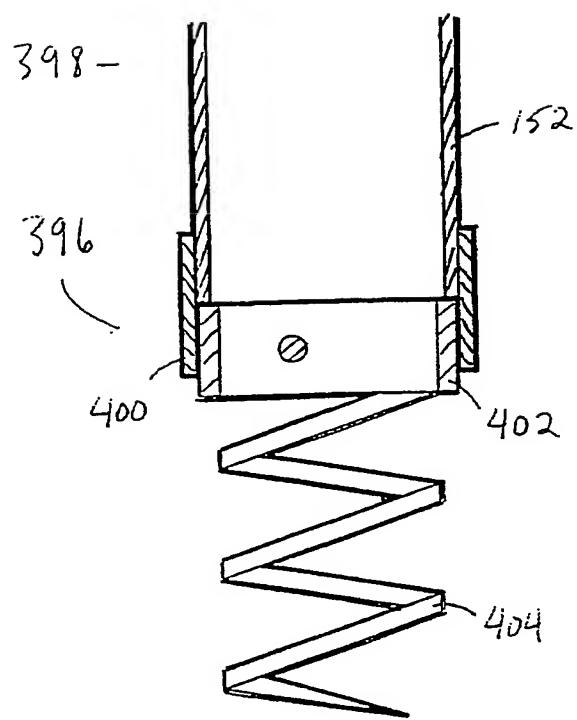


FIG. 20D

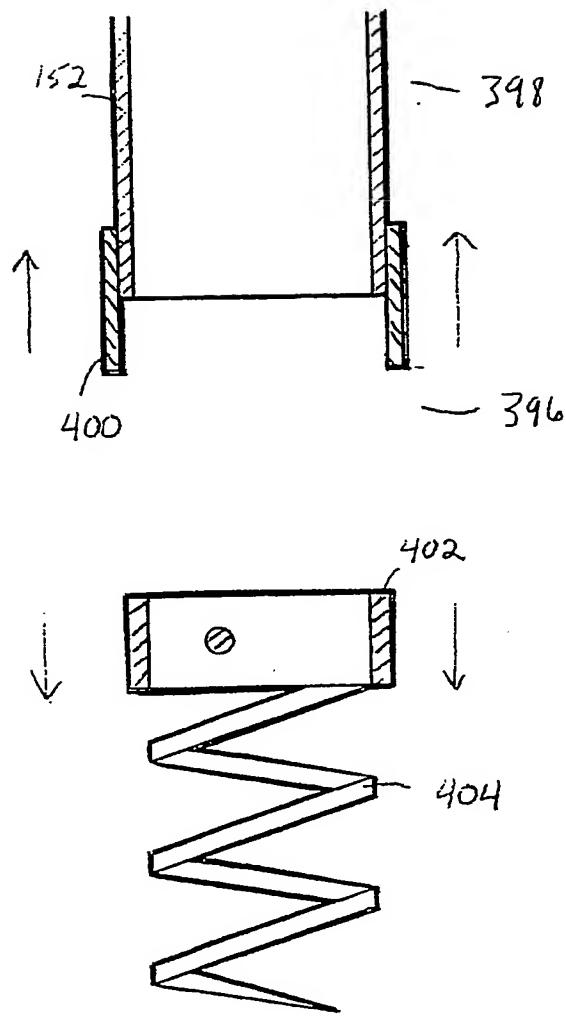


FIG. 20E

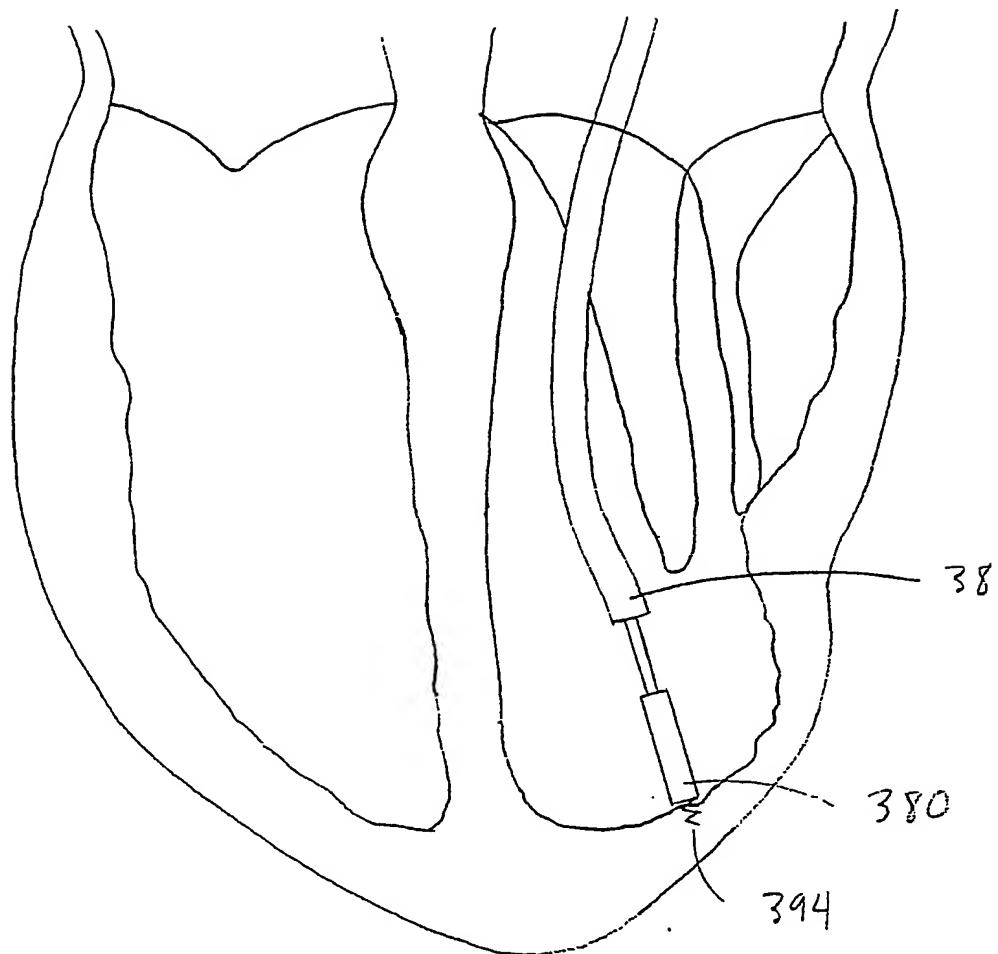


FIG. 20F

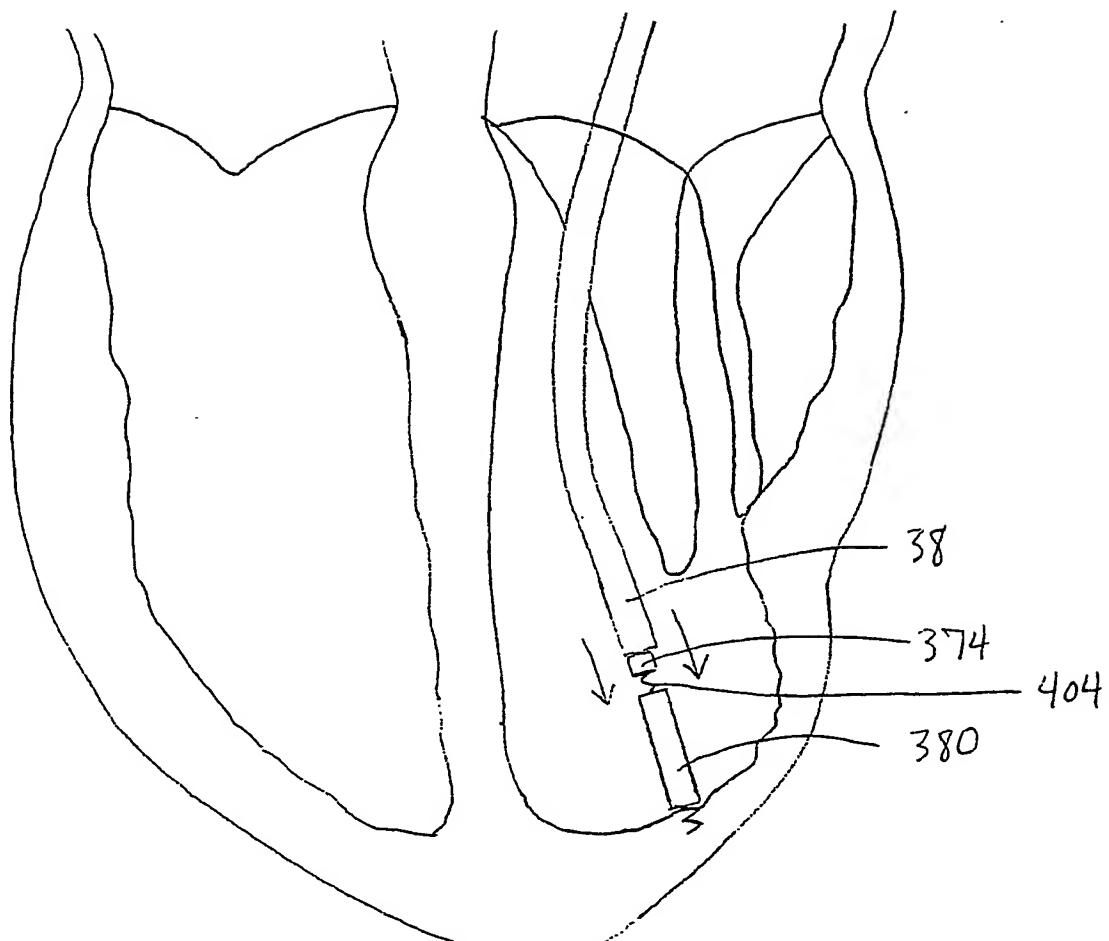


FIG. 20G

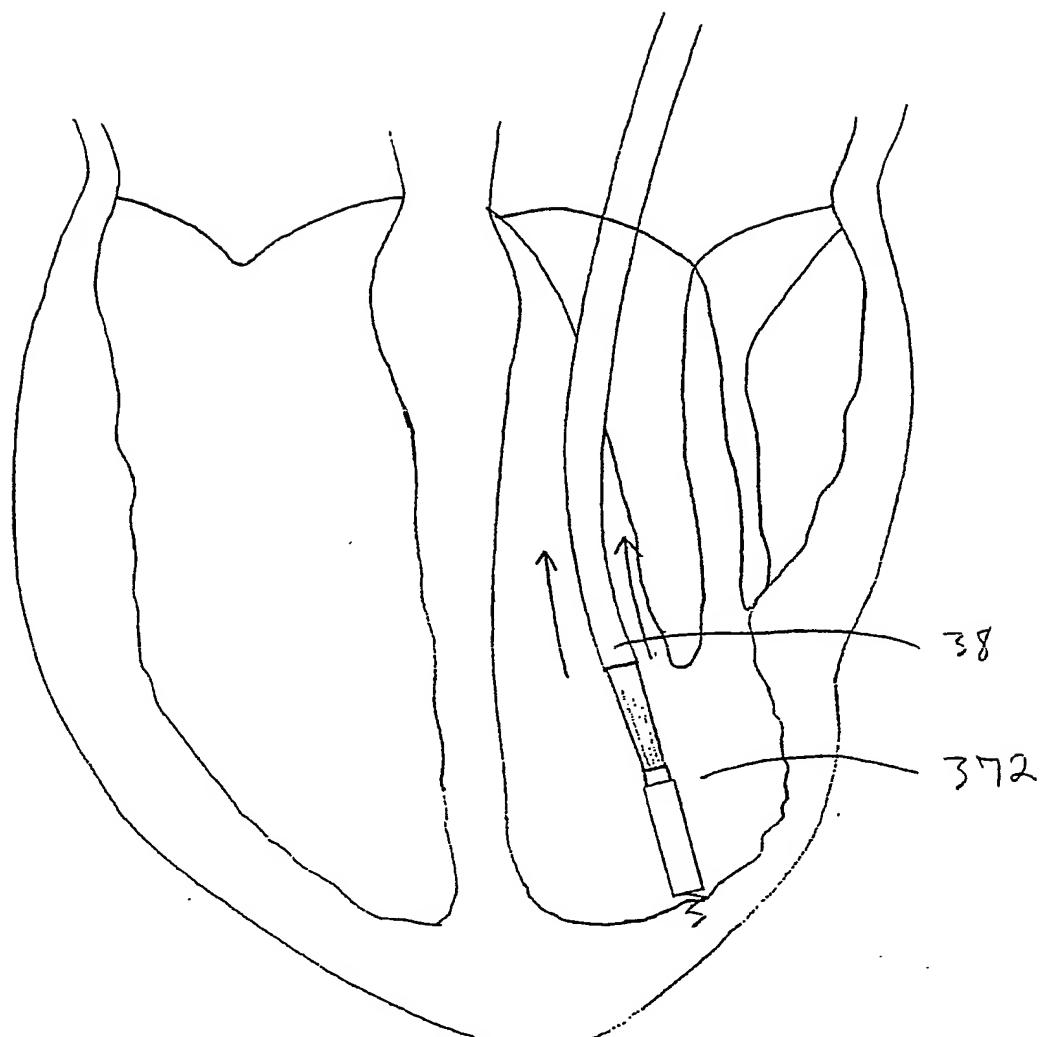


FIG. 20H

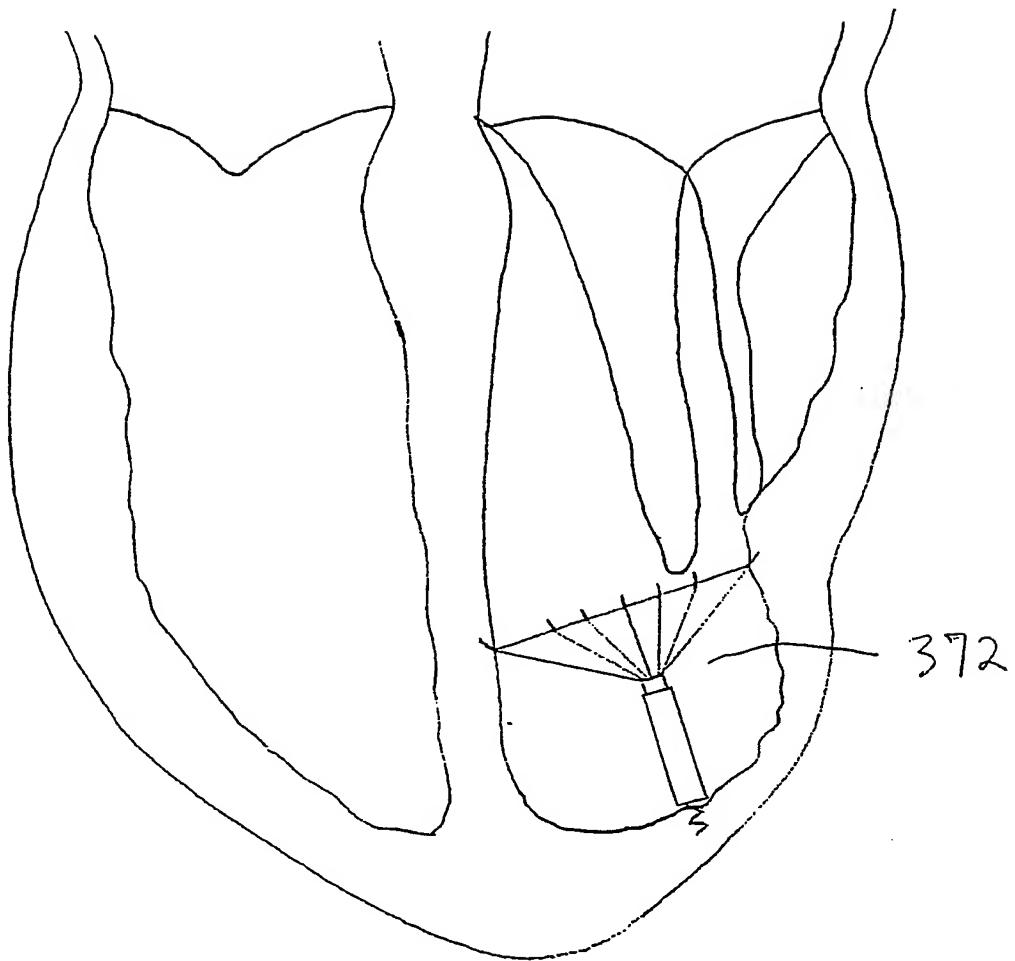


FIG. 20I

INTERNATIONAL SEARCH REPORT

ational Application No
/US2004/014782

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B17/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 00/27292 A (MV) 18 May 2000 (2000-05-18) page 5, line 17 – page 6, line 17; figures 1-4	1-90
A	WO 01/30266 A (ATRTECH) 3 May 2001 (2001-05-03)	
A	WO 02/30335 A (MYOCOR) 18 April 2002 (2002-04-18)	
A	US 3 874 388 A (KING) 1 April 1975 (1975-04-01)	

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

° Special categories of cited documents :

- °A° document defining the general state of the art which is not considered to be of particular relevance
- °E° earlier document but published on or after the international filing date
- °L° document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- °O° document referring to an oral disclosure, use, exhibition or other means
- °P° document published prior to the international filing date but later than the priority date claimed

- °T° later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- °X° document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- °Y° document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- °&° document member of the same patent family

Date of the actual completion of the international search

14 September 2004

Date of mailing of the international search report

21/09/2004

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NL - 2280 HV Rijswijk
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Fax: (+31-70) 340-3016

Authorized officer

Barton, S

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

/US2004/014782

Patent document cited in search report	Publication date		Patent family member(s)	Publication date
WO 0027292	A 18-05-2000	US	6152144 A	28-11-2000
		AU	771096 B2	11-03-2004
		AU	1715300 A	29-05-2000
		CA	2349667 A1	18-05-2000
		CN	1342056 T	27-03-2002
		EP	1135068 A1	26-09-2001
		JP	2003529384 T	07-10-2003
		WO	0027292 A1	18-05-2000
		US	2003220667 A1	27-11-2003
		US	2003199923 A1	23-10-2003
		US	2004098031 A1	20-05-2004
WO 0130266	A 03-05-2001	US	6551303 B1	22-04-2003
		US	6689150 B1	10-02-2004
		AT	264658 T	15-05-2004
		AU	1232701 A	08-05-2001
		AU	2119501 A	08-05-2001
		AU	2299001 A	08-05-2001
		CA	2386894 A1	03-05-2001
		CA	2388600 A1	03-05-2001
		CA	2388603 A1	03-05-2001
		CN	1384726 T	11-12-2002
		CN	1399530 T	26-02-2003
		CN	1399531 T	26-02-2003
		DE	60010105 D1	27-05-2004
		DE	60010105 T2	26-08-2004
		EP	1227770 A1	07-08-2002
		EP	1223890 A1	24-07-2002
		EP	1225843 A1	31-07-2002
		EP	1433437 A2	30-06-2004
		JP	2003529410 T	07-10-2003
		JP	2003512128 T	02-04-2003
		JP	2003512129 T	02-04-2003
		WO	0130266 A1	03-05-2001
		WO	0130267 A1	03-05-2001
		WO	0130268 A1	03-05-2001
		US	2003120337 A1	26-06-2003
		US	2003191526 A1	09-10-2003
		US	6652555 B1	25-11-2003
		US	2004127935 A1	01-07-2004
		US	2004049210 A1	11-03-2004
		US	2004122467 A1	24-06-2004
		US	6652556 B1	25-11-2003
WO 0230335	A 18-04-2002	US	6616684 B1	09-09-2003
		AU	9492101 A	22-04-2002
		EP	1322259 A2	02-07-2003
		WO	0230335 A2	18-04-2002
		US	2003181928 A1	25-09-2003
US 3874388	A 01-04-1975	AU	489252 B2	23-10-1976
		DE	2514142 A1	14-10-1976
		FR	2305165 A1	22-10-1976
		GB	1509023 A	26-04-1978
		AU	7953175 A	28-10-1976

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